DISCOVERY

JUNE 1957

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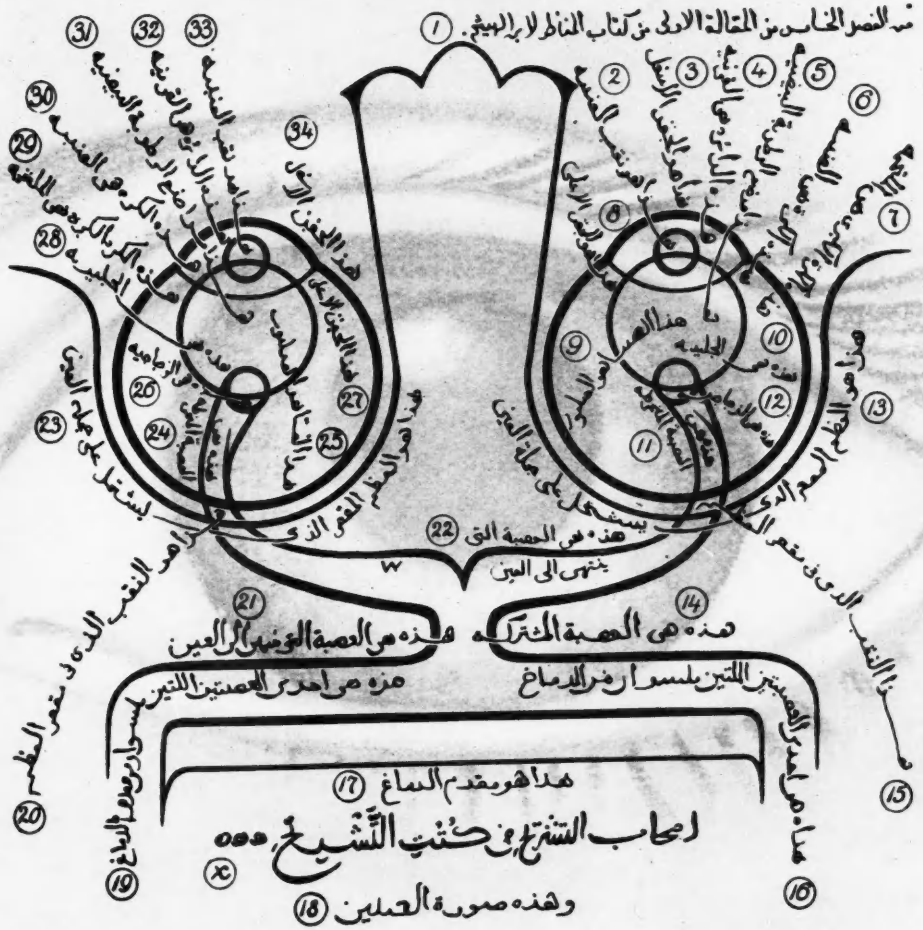

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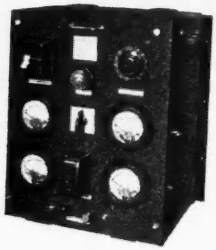

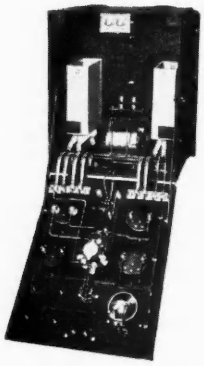

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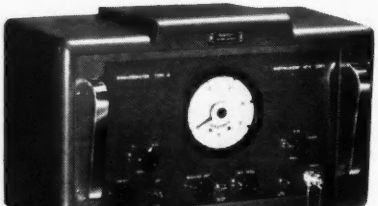

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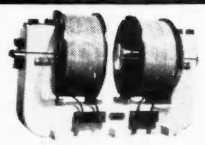

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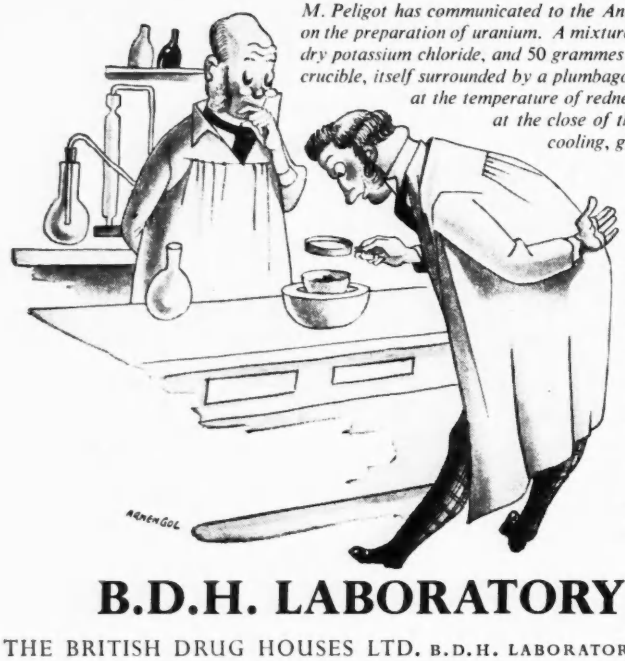
JUNE 1957 VOLUME XVIII NUMBER 6

CONTENTS

COVER PICTURE: Our cover this month shows an Arabic diagram, the oldest extant pictorial representation of the visual system, superimposed on a human eye. See p. 237 for the article on "Vision and Behaviour", and p. 238 for a complete translation of the Arabic caption.

M. Peligot finds uranium



M. Peligot has communicated to the Annales de Chimie et Physique (xvii, 363) a short note on the preparation of uranium. A mixture of 75 grammes of uranous chloride, 150 grammes of dry potassium chloride, and 50 grammes of sodium in fragments is introduced into a porcelain crucible, itself surrounded by a plumbago crucible. The reaction is effected in a wind furnace at the temperature of redness; but the heat must be increased for a short time at the close of the operation. In the black slag may be found, after cooling, globules of fused uranium.

The new method of producing uranium was announced in the first issue of Nature in 1869. Monsieur Peligot, who twenty-eight years before had first isolated the metal, discovered by Klaproth in 1789, was opening the door a little more widely to the possibility of an Atomic Age a century later.

In recent years the priority attaching to the atomic energy programme has restricted their availability, but uranium compounds are now again available and figure among the several thousand fine chemicals of very high purity supplied by B.D.H. for science and industry.

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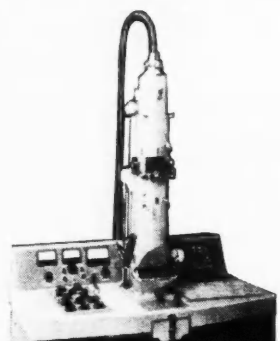

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THE PROGRESS OF SCIENCE

THE RETREAT OF THE BBC

The recent announcement by the British Broadcasting Corporation that it intends to curtail its output on the Third Programme is an extremely regrettable and retrograde step. The contribution of this internationally acclaimed programme to science is ably reviewed on another page of this issue by a member of the BBC's staff. We feel, however, that this factual statement needs our own editorial comment, at a moment when it looks as if the BBC is beginning to run away from the responsibilities it has so far taken so seriously. Particularly at present, when the need for first-class communications between scientists and the public are stressed by all, one would have expected that any changes the BBC felt obliged to make would be in the direction of more talks and less music, rather than the opposite course, which has now been proposed.

The nebulous announcement about the "Network Three" is hardly likely to appease all those thoughtful people who feel that the present proposals are pandering to lower intelligence, rather than helping to encourage more constructive thought. Communication between specialists, the avowed purpose of "Network Three", has in any case always been excellently catered for, at least in the scientific disciplines, by the great number of special journals, and it is unlikely that "Network Three" will be able to contribute anything further in this narrow field. What is wanted is that the sciences and the arts should intermingle in discussions and thus stimulate each other to their mutual advantage. No! The BBC is falling back, and by lowering the standards of sound broadcasting is coming down to the admittedly unsatisfactory level of television.

During recent visits abroad we were often complimented on the valuable contribution the BBC had made, and was still making, to the culture of Britain, and several scientists in France and Switzerland had tuned in to scientific broadcasts of the Third Programme; they felt that these were a unique contribution to their knowledge. The very division into three levels, Light, Home, and Third, has been an outstanding factor in the whole of British broadcasting. This division should be further developed, and science should be given its due place on the air in all three programmes, with contributions designed to suit different audience interests, so that science can take its rightful place among the cultural activities of this country. It is indeed lamentable that the BBC should see fit to curtail the Third Programme, and thus necessarily reduce the time given to science on the air.

Unfortunately, the days are past when its imaginative and courageous approach secured the Corporation an unquestioned place in the intellectual life of the country, and it appears as if the many years of monopoly have left its leaders unprepared to take up the challenge of competition. It should be remembered that it is the success of the Independent Television Authority that has been indirectly responsible for the changes in BBC policy which are now under discussion. As a further example one might quote the television series for schools, at the moment being broadcast by Associated Rediffusion; they rightly include a scientific series of eight programmes dealing with the International Geophysical Year. The BBC, sadly lagging behind, has promised a school science series for the autumn term.

It would be misleading if these comments were interpreted as a general criticism of the BBC at all levels. Imagination and first-class radio are still to be found in many of its daily programmes, due to the unstinting and devoted efforts of its outstanding producers, often working under great difficulties. Their labour should serve as inspiration to those responsible for the BBC's policy, so that the largest broadcasting organisation in the world can again lead, instead of retreat.

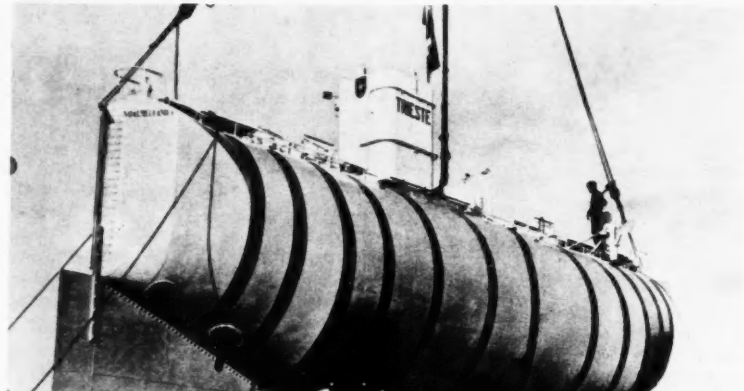
U.S. NAVY TO SUPPORT BATHYSCAPHE

Welcome news was released at the end of February that the U.S. Navy had decided to support Piccard's bathyscaphe research work. Only two of these interesting deep-ocean research vessels have so far been built, both closely based on the original design of Prof. A. Piccard. The bathyscaphe is the under-water equivalent of a lighter-than-air craft, like the historic balloons, the Zeppelins, and the blimp. A streamlined flotation hull is filled with petrol, which gives it buoyancy, and beneath this hull a forged-steel sphere is suspended, of two metres diameter. At the beginning of the dive, containers with metal ballast are filled, just sufficiently to allow the craft to sink at a predetermined velocity. The bottom of these containers is closed by an electromagnetic device which can be opened from the inside of the sphere. On reaching the bottom, the whole craft can be propelled forwards and backwards by externally situated electric motors and propellers, and it can be brought to the surface again by emptying the containers of the ballast.

The first of these bathyscaphes was originally constructed by the Belgian National Research Council, and in conjunction with the French Navy extensive trials were carried out. A disagreement on technical points arose, however, between Prof. Piccard and the French Navy, and the craft was taken over by the Naval Development Branch at Toulon. The French scientists Willm and Houot* were placed in charge, and after numerous modifications were carried out they succeeded in making the craft seaworthy and in performing the deepest dive yet recorded, of four km., near Dakar. In the meantime, Prof. Piccard, in conjunction with his son, J. Piccard, raised the necessary funds for the construction of a second bathyscaphe, the *Trieste*. It is the *Trieste* which the American Navy has now decided to support in its research work.

Exploration of the great oceanic depths has up to now suffered from the fact that the considerable funds necessary for this work were not available. The *Trieste*,

* Willm, P., and Houot, G., "Le Bathyscaphe", Paris, 1954. "Two Thousand Fathoms Down", Hamish Hamilton, 1955.



Left: The bathyscaphe *Trieste*, an underwater research craft designed by Prof. Auguste Piccard and his son Jacques. During 1957 the *Trieste* will make a series of dives in the Mediterranean area under contract with the American Office of Naval Research. *Bottom:* Prof. Auguste Piccard and his son, Jacques. (*Both illustrations on this page are official U.S. Navy photographs.*)

so far financed partly by Swiss and partly by Italian funds, has lain for many months unused because the great expenditure for petrol, constructional improvements, and auxiliary naval operations, was too high. A research grant from the U.S. Navy should therefore allow scientific research work to go ahead. It is proposed that during the International Geophysical Year fifteen dives should be made off the coast of Italy, and that detailed marine geological and geophysical surveys should be carried out at great depths. It is hoped that American, Italian, Swiss, and other European oceanographers will participate.

THE CRYOTRON

Low-temperature research has led to the development of the cryotron, which can serve as a nearly perfect electronic switch. Work on this interesting development is going on at the moment at Arthur D. Little, Inc.,* Cambridge, Massachusetts. In its simplest form, the cryotron consists of a straight piece of wire approximately one-tenth of an inch long, wound with a single layer of control wire about the size of a human hair. This very small device may have far-reaching influence on the future development of electronic computing machines.

The cryotron operates in a bath of liquid helium, only a few degrees above absolute zero; at such extreme low temperatures, many metals are said to be superconductive, that is, they offer no resistance to the passage of electrical current. A metal that has been cooled to the superconducting state regains its normal resistance in the presence of a sufficient magnetic field. When the cryotron is cooled by liquid helium, the central wire can be made superconductive or resistive at will by raising

* This note is reproduced from the *Industrial Bulletin*. No. 334, of Arthur D. Little, Inc., by kind permission of the Editor.

or lowering the magnetic field created by the control current flowing in the surrounding coil. Thus the cryotron performs the same functions as any electronic switch—it makes, breaks, or changes connexion in an electrical circuit.

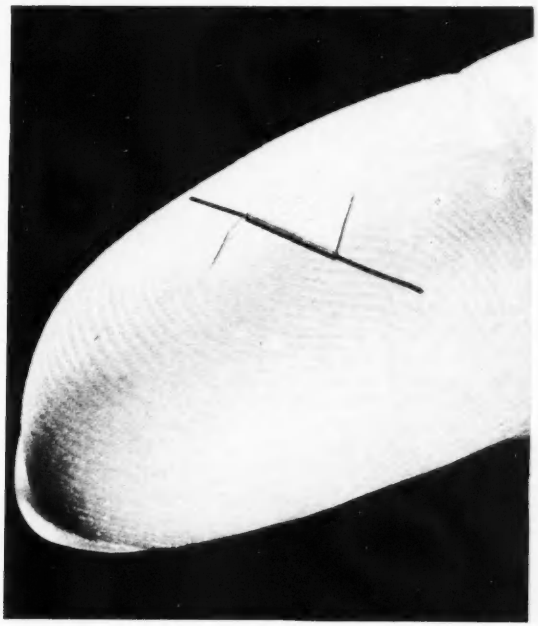
As a passive switch, one that simply turns electrical current on or off, cryotrons can compete favourably with transistors and diodes, whose resistance when "open" can be 100,000 times higher than when "closed". The cryotron offers the possibility of an entirely new concept of switching circuits; its ratio of open to closed resistance is theoretically infinite.

The cryotron can also function as an active switch or current amplifier, in that it can control a larger current than is required for its own actuation. Thus, great numbers of cryotrons can be interconnected to form the logical network of an electronic computer, as can vacuum tubes and transistors. So far, cryotrons have been unable to match either of these devices in switching speed, although their unusually small size, exceptionally low cost, and high reliability make them more attractive than transistors and vacuum tubes for many applications. It may one day be possible to build a large-scale digital computer that will occupy only one cubic foot, exclusive of refrigeration and terminal equipment. This represents a space saving of approximately 20 to 1 compared to transistor computers, and perhaps 300 to 1 compared to vacuum-tube computers.

Getting rid of unwanted heat is an important consideration in electronic computer design. It takes an average of two watts of otherwise "useless" power to heat up the filament of a vacuum tube so that it will operate; this poses a severe problem of heat dissipation in a multi-tube computer. By contrast, the heating requirement is only a few thousandths of a watt for transistors and only one-hundredth of that for cryotrons. A large-scale digital cryotron computer may give off as little as 0·5 watt of heat totally, again excluding terminal equipment and refrigeration. The power expediture in a cryotron computer is almost zero, moreover, since currents flow only in superconducting paths where the electrical resistance and power wastage is vanishingly small.

Because the cooling requirements for the cryotron are so small, it appears that liquid-helium-refrigerated computers may be commercially feasible. An adequate supply of liquid helium can be stored easily, compactly, and safely; with suitable refrigeration equipment, the helium would not have to be replenished frequently.

One of the first applications of the cryotron will be in an electronic catalogue or memory that will store about two thousand "words" of information in appropriate categories. (One "word" consists of a number of letters or characters, each in the form of a binary code, which is the universal "language" of electronic computers.) When questioned, the machine will tell whether a particular word is contained in its memory, and, if so, in which category. A later modification of this machine might be a mail order catalogue that would "remember" the stock number of many items and keep an account of the quantity on hand. Another early application will probably be an automatic dictionary for literal translation of foreign words and phrases.



The cryotron, shown here on a lady's finger, is so tiny that 100 of them will fit into a thimble.

Although cryotrons show considerable promise for electronic computation, it is too early to estimate the extent of their commercial practicability. For some uses, their operating speed is now too slow; conceivably, it can be increased at least a hundredfold by further research and development.

WILLIAM HARVEY, FATHER OF EXPERIMENTAL MEDICINE

In this, the tercentennial month of his death, scientists the world over are paying homage to William Harvey, discoverer of the circulation of the blood. It is fit and proper that he should be remembered also by the public at large, for his brilliant work has in perpetuity benefited all mankind. To the lay mind the appellation "discoverer" might, perhaps, suggest that Harvey came upon the truth by accident, but this was certainly not the case. The way of the investigator was arduous and long. Had he not possessed the courage to question old and cherished beliefs, the power of observation, the patience to design, perform, and correlate innumerable experiments, and the ability to profit from clinical experience, this fundamental discovery might well have been delayed, possibly for another century. Harvey's claim to fame rests not upon his discovery of the circulation alone but on equally important and far-reaching research on generation and on his being the exemplar of the scientific method incarnate.

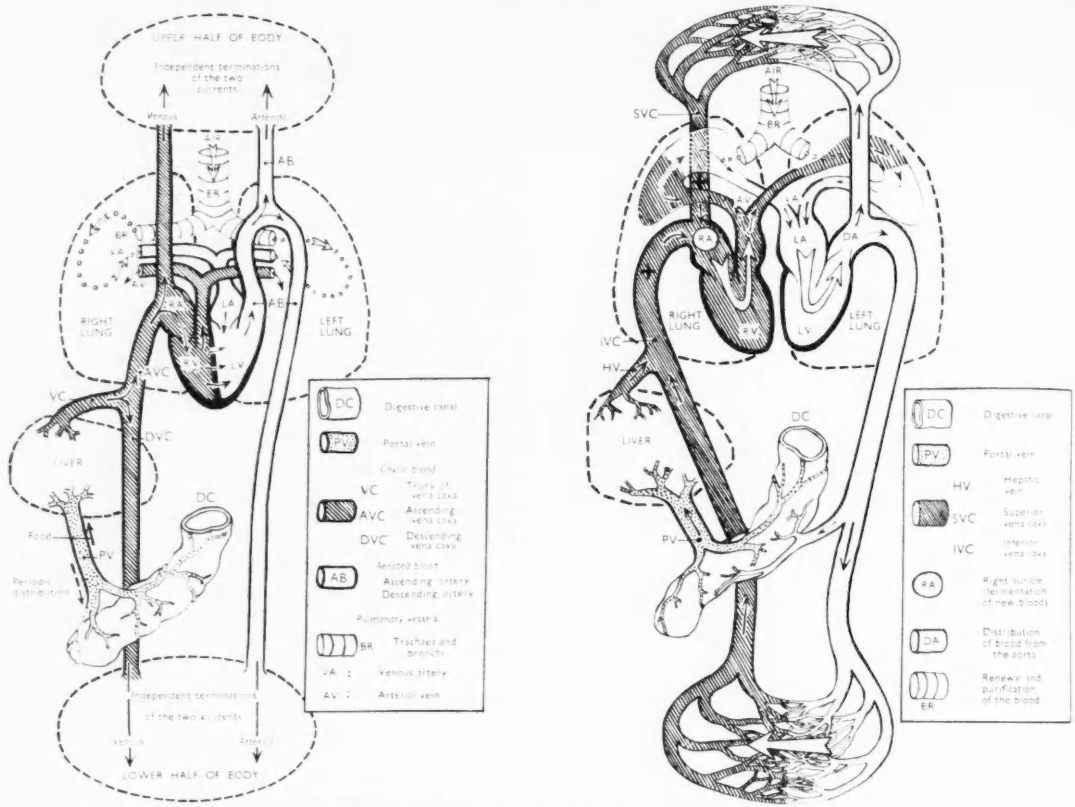


FIG. 1. The traditional system of the movement of the blood as taught by Galen in the second century A.D. Galen's fundamental error was the assumption that the left and right ventricles are connected by perforations through their dividing wall RA, LA: right and left auricles. RV, LV, right and left ventricles.

FIG. 2. The circulatory system of the blood as taught by William Harvey in the seventeenth century. Harvey conceived the circulation as starting at the point marked by a cross in the *inferior vena cava*, to the left of the RA. (These two illustrations are taken from Dr. Louis Chauvois' biography, "William Harvey", recently published by Hutchinson Medical Publications. Dr. Chauvois is a famous French medical historian.)

William Harvey was born at Folkestone, in Kent, on April 1, 1578, the son of well-to-do parents who sent him to King's School, Canterbury, where he acquired his lifelong love of the classics. He studied at Cambridge, and in 1600 went to Padua, at that time the most renowned school of medicine in the world, where he learned the art of dissecting the human body from Fabricius ab Aquapendente. One of the greatest anatomists of all times and a pioneer in embryology and comparative anatomy, Fabricius is famous for his discovery, in 1574, of the valves in the veins. Though his signature is writ large across many pages of the story of anatomy, curiously enough his name has become attached solely to "Fabricius's ship"—the fanciful resemblance of the contours of the occipital, sphenoid, and frontal bones of the skull to the outline of a ship. After graduating M.D. at Padua in 1602, Harvey returned to England, and in the same year obtained the M.D. at Cambridge. In 1607 he became a Fellow of the College of Physicians of London; and in 1609, at the age of 31, was elected physician to St Bartholomew's Hospital. Well read not only in the classics but also in the medical writings of the ancients, he was quick to appreciate that the works of his predecessors contained much that was incorrect, and no small part of his task was to avoid slavish acceptance of dogmatic opinions which continued to be perpetuated.

Four centuries before Christ, the "Father of Medicine" Hippocrates, had recognised the heart to be a muscle, but had ascribed the pulse to movement of the blood vessels. A century later, Aristotle looked upon the heart not only as the centre of the vascular system but also as the focus of the heat of the body and as the seat of intelligence. Erasistratus, the "Father of Physiology" (about 290 B.C.), described the valves of the heart, but believed that the arteries contained air. That gifted experimenter and distinguished biologist, Galen of Pergamum, the "Prince of Physicians" (about A.D. 150–200), asserted that "vital spirits" were formed when air was sucked into the left ventricle from the lungs—a view first challenged by Leonardo da Vinci.

William Harvey engraved by C. H. Jeans in 1870 from a contemporary portrait now in the library of the Royal College of Physicians. This illustration is also taken from Dr. Chauvois' book.

The "Father of Modern Anatomy", Andreas Vesalius, stated in the second edition of his classic, "De humanis corporis fabrica" (1555), that he could find no communication between the ventricles of the heart. Michael Servetus, who in 1553 was burnt at the stake for his religious heresies, first described the lesser or pulmonary circulation. Harvey's teacher, Fabricius, published his book on the valves of the veins in 1603. Though he failed to recognise their true function, believing their purpose to be to prevent the blood from flowing in the veins to the extremities, his work stimulated Harvey's attempts at demonstrating the circulation experimentally.

Thus there were three erroneous beliefs that stood as barriers between Harvey and the truth: that the arteries contained air; that the septum between the two ventricles of the heart was perforated; and that the blood was carried along the veins to the periphery of the body. In 1615 he was elected Lumleian Lecturer at the College of Physicians, and it is clear from the notes for these lectures, which are still extant, that he had already arrived at several important stages on the road to his discovery. He concluded that blood can pass from the arteries to the veins; that the flow in the reverse direction is prevented by the valves of the heart, which he realised was a muscle; and that the heart-beat is responsible for "a perpetual motion of the blood in a circle". He pursued his activities as medical practitioner and lecturer for many more years, while still conducting experiments and performing dissections. When at last he felt ready to make known to the world the results of his labours, he published in 1628 at Frankfurt-am-Main a small volume of 72 pages which is generally considered the most important book in the history of medicine. "Exercitatio anatomica de motu cordis et sanguinis in animalibus" is a modest title, for the work is so much more than an anatomical exercise, representing as it does something the like of which had not been seen before: an account of a complete experimental investigation which details every step in the unravelling of a vital process.

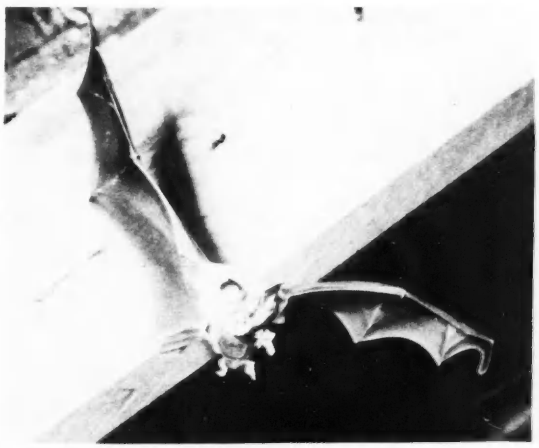
Harvey proved with absolute finality that blood passes from the arteries into the veins and that "the movement of the blood is constantly in a circle, and is brought about by the beat of the heart". The "pores", which he describes for the passing of blood from arteries to veins, correspond to the capillaries seen by Marcello Malpighi with the microscope in 1660.

At the end of the Civil War, Harvey retired from practice and continued his researches in embryology. He was physician to James I and to Charles I. He declined the presidency of the College of Physicians in 1654 because of age, but left much of his estate to the College, part of this to establish the annual Harveian Oration. He died at Roehampton on June 3, 1657.

Extensive celebrations will take place to commemorate the tercentenary of Harvey's death, and a special congress will be organised by the Royal College of Surgeons. Receptions by London University, Her Majesty's Government, and the President and Council of the Harveian Society have been arranged; the celebrations will include a closed-circuit colour television demonstration and a transatlantic telephone link-up between the American Medical Association, meeting at Carnegie Hall, New York, and the Congress in London.

BAT-BANDING IN DEVON

For many years past, ornithologists have fitted numbered bands to birds to learn something of their movements and migrations, and this same technique has been adopted by naturalists wishing to study the habits of bats. The pioneer in such work was probably A. A. Allen, the American ornithologist, who, in 1916, attached bird bands to the legs of five bats. Similar small-scale



A Greater Horseshoe bat in flight with her baby clinging to her underside.

Left: Young Greater Horseshoe bat approximately two weeks old. *Right:* Young Greater Horseshoe bat clinging to its mother with teeth, feet, and wings. All these photographs are the copyright of J. H. D. Hooper.

experiments of this nature were later undertaken by other naturalists, but it was not until 1932 that banding of bats was commenced on a large scale, both in Europe and America. Eisentraut, for example, banded nearly 11,000 bats in Germany between 1932 and 1942, while in America, D. R. Griffin and his associates, who started at about the same time, have banded over 13,000 bats, mainly in caves and mines in New England. Published figures show that between 1932 and 1951, 67,279 bats were banded in the U.S.A. and Canada, and of this total, 50,021 were banded in caves. In Europe, the large-scale experiments of Eisentraut in Germany have now been surpassed by the efforts of Bels and his co-workers in Holland who have banded over 20,000 bats in subterranean tunnels in the South Limburg area. In many other countries also, including Belgium, France, Sweden, Switzerland, Poland, and Britain, bat-banding studies have been carried out, although on a rather smaller scale.

In Britain, bat-banding work is now being carried out in several areas, notably Devon, Somerset, N. Wales, and Derbyshire, but such work is comparatively recent and did not really start until 1947. In that year, members of the Devon Spelaeological Society began tentative experiments, using home-made rings, on the bats that inhabit some natural limestone caves at Buckfastleigh. As a result of these trials, a more intensive study was undertaken in September 1948, using standard, aluminium bird-bands. An account of the early results of such work was given in DISCOVERY in 1949. Since that time, the work in Devon has made considerable progress and by the end of 1954, 2040 bats, representing seven different species, had been banded in some ninety haunts scattered between the Dorset and Cornish borders of S. Devon. An account of this work up to December 1954 has recently been published by J. H. D. Hooper and W. M. Hooper.

The bats most commonly found in the Devon caves are the two British representatives of the family *Rhinolophidae* (leaf-nosed bats). These two species are the Greater Horseshoe bats (*Rhinolophus ferrumequinum*) and the Lesser Horseshoe bats (*R. hipposideros*). The Greater Horseshoe is one of the larger British bats, with a wing span that sometimes reaches 14 inches and is characterised by a curious leaf-like nasal membrane, shaped in the form of a horseshoe. The Lesser Horseshoe bat is very similar in appearance, but is smaller, having a wing span of the order of 9 inches. In the period under review, 1364 Greater Horseshoe bats were banded in Devon, and of this total, no less than 851 have been found again. This surprisingly high level of recovery (approximately 62%) has been maintained for several years. Many bats, of course, have been recovered several times, including one individual which developed into quite an "old friend", since it was handled sixteen times in the years following its original date of banding.

During the same period, 597 Lesser Horseshoe bats were banded, but for these the recovery has been rather smaller, only 167 (28%) having been found again.

The method of banding employed in Devon follows the system now generally practised by bat workers and makes use of a thin band of aluminium, shaped like a letter "C", which is placed round the wing bone of the forearm of the bat, the two ends being gently squeezed together, until they meet against, but do not puncture, the wing membrane. For Lesser Horseshoe bats, it has been found possible to use the standard size of ring as made for the smallest birds, and this weighs about 0·05 gram. For Greater Horseshoe bats, a slighly larger ring is necessary. Such rings are numbered consecutively, and also bear the identifying initials "DSS" (Devon Spelaeological Society).

Interesting information is coming to light concerning the movements of the Horseshoe bats. It has been found that although individual bats may commonly show an apparent preference for some particular cave, they are on the other hand equally likely to fly to alternative haunts some distance away. Flights of up to 10 miles are moderately common for Greater Horseshoe bats, but several movements of 15 to 20 miles have been recorded in Devon, and one such bat, by making a double journey between two places no less than 40 miles apart has provided evidence that the Greater Horseshoes probably range over a much larger area than is at present realised. For bats of this species, 440 movements longer than one mile have been recorded in Devon, and roughly one-third of these movements have taken place during the winter months. It has in fact been clearly demonstrated that the so-called "hibernation" of such bats is far from deep, and is certainly only intermittent.

Nevertheless, the Horseshoe bats do show greatly reduced activity during the winter period, and weighing experiments carried out during four successive winters in Devon showed that there is a marked decrease in weight between December and April. In mid-December, the female Greater Horseshoe bats are about 2 grams heavier than the males, average figures being 23·5 and 21·5 grams respectively, but by the end of April, the mean weights for both sexes have fallen to approximately 16 grams, corresponding to a loss of 25 to 30%. From May onwards, the weight starts to build up once more, and with the onset of warmer weather, the bats leave the caves and scatter to unknown haunts, probably in house roofs. In the summer they are very difficult to find, but it has been established that in July the females gather together in large clusters in certain established haunts and form "nursing colonies" where the young are born. For the first month or so of its life the young bat is carried by its mother, clinging to her underside while she is in flight. However, when the adults fly out to hunt at dusk, they commonly leave their offspring behind—and it is sometimes possible to enter a barn roof and find a cluster of helpless baby bats, clinging to the rafters and squeaking loudly for their absent parents. The latter no doubt are duly relieved at being able to fly unencumbered—for weighing experiments in Devon have shown that the mother often has to carry a hefty "baby" weighing fully half her own weight.

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SYNTHETIC RUBBER

An international synthetic rubber symposium, organised by the "Rubber and Plastics Age", was held in London at the end of March. It was attended by over six hundred delegates, including many from North America and Europe. Sixteen papers were presented. It is not proposed in this report to summarise the large amount of scientific and technical information that was communicated to delegates, but only to present items of general interest.

By the end of next year Britain will be making over 80,000 tons per annum of synthetic rubber; 50,000 tons per annum will be general-purpose rubber to be made at Fawley, near Southampton, and the remainder will consist of speciality rubbers manufactured by several firms, some of which are already in production. Hitherto nearly all synthetic rubber used in Britain has been bought from Canada and the U.S.A., so these developments are of economic as well as technical importance.

A German plant designed to produce 45,000 tons per annum of general-purpose synthetic rubber was also described.

A new self-reinforcing elastomer, Kryflex 252, has been developed in Canada. This material is a styrene-butadiene copolymer containing 39% of styrene, compared with general-purpose butadiene-styrene rubbers, which have about 25% styrene content. When Kryflex 252 is mixed with either natural or butadiene-styrene general-purpose rubber and compounded with suitable fillers, the vulcanised product obtained is eminently suitable for shoe-soling materials. Kryflex 252 has processing advantages over the high styrene resins which are now used in the so-called resin-rubber soles. At present about 25% of the shoes manufactured in Great Britain have non-leather soles, but from experience on the North American continent it seems likely that this proportion will be trebled in the next few years.

Energetic efforts are being made in the United States to develop butyl as a general-purpose synthetic rubber. Originally butyl found outlets in products where its properties, including low permeability to gases and resistance to many chemicals, were particularly important. Delegates to the symposium were told of progress in the development of butyl tyres, and learnt that many of the numerous technical problems have now been surmounted. Very good tyres made from butyl rubber are already in use. Butyl latices, previously not available, have been developed.

In the development of commercial synthetic rubbers, no attempts were made to synthesise the natural rubber molecule. An American rubber, Ameripol SN, was described at the symposium, and in this rubber the

chemical and physical properties of natural rubber have been reproduced. Ameripol SN is made by polymerising very pure isoprene in solution in a solvent such as heptane. A Ziegler-type catalyst, titanium tetrachloride and an aluminium alkyl, is used, and the rubber is precipitated from solution by acetone. This method of preparation is in contradistinction to the emulsion polymerisation techniques used in the manufacture of the majority of synthetic rubbers. In order to obtain technological properties similar to those of natural rubber it is necessary to add chemicals to simulate the non-rubber hydrocarbon constituents of the natural product. Three types of materials are added: antioxidant, protein, and fatty acid. The plant used for making Ameripol SN has a capacity of about 500 tons per annum, but this rubber cannot be made economically until the price of the raw material, isoprene, is lowered.

Professor Natta, from Italy, gave an account of new polymerisation processes he has developed, in which new polymers have been prepared using stereo-specific catalysts.

Other papers were concerned with descriptions of new, or relatively new, specialised synthetic rubbers. Some of these have already found their niche in the rubber industry for the manufacture of articles where the particular properties required cannot be obtained by using natural or general-purpose synthetic rubbers.

Opinion is that natural and synthetic rubbers are complementary and will remain so for very many years. Each year the rubber-manufacturing industry needs larger quantities of rubber, and neither synthetic rubbers nor the natural product alone can supply the demand.

A 275-kilowatt pylon under test in the "Monkey Hole".

THE "MONKEY HOLE"

The new testing station for tall structures, recently completed by Stewarts and Lloyds at Wirksworth, in Derbyshire, is unique in this country. It has always been difficult to test masts and towers effectively, because of the need to have a point of support for the rope at the same height as the structure when applying horizontal loads. Many tests are carried out to destruction, so the supports for the horizontal loads must be much stronger than the structure to which the load is applied. In addition, it is usual to apply these loads in two directions horizontally at right angles, and a minimum of two strong towers of similar height to the one under test would be needed if the tests were carried out on level ground. The alternative is to use some natural feature which provides high ground in the immediate vicinity of the testing station, such as two cliffs at right angles, or a quarry.

Such a quarry was available at Wirksworth. It is entered through a narrow cleft in the face of a limestone cliff, some 150 feet high, and proved to be the ideal site. The walls are nearly vertical and the floor is rectangular, some 100 feet by 60 feet. The quarry is called the "Monkey Hole". The story is that many years ago an Italian organ-grinder and his monkey used to entertain the quarrymen from the bridge which spans the entrance. Then the monkey would be lowered on a string to make a collection. One day the string broke—and that was the end of the monkey, and the beginning of the present name of the quarry.

A universal type of base has been constructed to accommodate a large variety of towers. Bolts can be screwed into sockets, which are flush with the concrete base, and the tower footings can then be picked up at the required point. Because of the high walls of the quarry, the tower is tested in virtually still-air conditions. Loads equivalent to the wind loads can be applied without having to make allowance for the wind at the time of testing.

If a tower taller than 150 feet is to be tested, ropes can be carried back to the rising ground around the quarry, or small structures erected to enable horizontal pulls to be applied up to 200 feet above the quarry floor. Higher structures can be tested by dealing only with the top part or by using half-scale models. The maximum width across the cross-arms is limited to 50 feet for towers up to 100 feet high, but above this height the width can be considerably greater.

Loads up to 30 tons are required for some tests, so the anchorage points had to be made very secure. The numbers of these points installed will increase as the various tests call for them, until finally there will be sufficient anchorage points to allow any structure to be picked up, if not exactly at the right level, then by a bridle spanning two anchors. After a number of tests, the type of anchor selected was found capable of withstanding a

direct pull of 94 tons, at which point the eye of the anchor broke, but there was no sign of the anchor itself being disturbed in its rock setting. In very few cases will the load be applied in such a way as to pull an anchor straight out of the rock. Normally, the anchors will carry a pulley converting the horizontal load into a vertical one, and the resultant pull will be at about 45° or less to the line of the anchor.

The number of loading-points and the maximum load at any one point were problems to which much consideration was given. It was eventually decided that twelve points would be needed, and that the load at any one point would not exceed 30 tons. This could best be obtained by a 5-ton pull, multiplied by the usual arrangement of multi-sheave blocks.

Ordinary commercial winches were not suitable, as the tests would need a large load to be applied very slowly, the opposite of the usual winch application. Special gears were provided to keep the rope speed very slow—about 1¼ feet per minute. Each of the twelve winches is powered by a 2-h.p. motor, running at 960 r.p.m. The main drum makes only half a revolution per minute. The maximum load per winch is 5 tons, but many of the loads are usually less than this. Should more than twelve loading-points be required, one winch can be used to serve several points at the same time, while loads in excess of 30 tons can be obtained by coupling a number of winches and anchor-points together.

The building which houses the winches and switchgear extends across the end wall, opposite the entrance; the control-house is immediately above it. Sloping windows of armour-plate glass are provided for observation and give a clear view of the test area. The winches are under push-button control, both at the winch itself and remotely in the control-house above. During a test, the ropes run out from each winch, and then across the quarry floor and up to the appropriate loading-point. The multiplying tackle is provided as near as possible to the loading-point. This reduces the load on the anchors and other points.

On the main control desk dials show the load at each of twelve selected points and the deflection at ten points on the structure under test. In front of the main operator is the schedule of testing, a microphone through which he can give directions to different parts of the quarry, and an emergency "stop everything" button which cuts off power to the winches, plus a single button to release all loads simultaneously.

Two other operators control the winches from the wing desks at each side. A permanent record of the dial readings at any stage of the test can be made by cameras mounted to photograph either wing. The whole sequence of operations, the commands given, and the values of the loads applied, can be registered on a tape recorder.

Much thought was given to the problem of measuring the loads applied, and particularly to the accurate indication of these loads in the control-house. The device adopted consists of a form of differential transformer capable of measuring a very small linear displacement, which is, in fact, the elastic extension of the tubular outer casing of the device, occurring as the load is applied. The load is proportional to this extension and the instrument indicates in tons the applied load. The "pullmeters", as they are called, are self-contained, weatherproof, easily calibrated, and operate on the ordinary 50-cycle mains with relatively large voltages compared with the much smaller voltages involved in electric resistance strain-gauges. The sensitivity is such that the indicator will move for a change in load of one part in a thousand. The error of the instrument does not exceed plus or minus one per cent of the full load.

Accurate deflection is measured by electrical indication of the rotation of the pulleys, and is shown on the dials in the control-house. The sensitivity of the apparatus is such that a movement of 0·05 of an inch is detectable, and the accuracy of the readings is about plus or minus one-tenth of an inch.

Additional equipment in the control-house can be used for special tests. Strain-gauges attached to appropriate points on the structure can be used to record stresses induced. Vibration tests can be made, and the alternating stresses recorded in the control-house. If necessary, these tests can be carried out to destruction to give an estimate of the life of the structure under varying stresses. Photographs can be taken during the test, and a detailed inspection of the structure can be made through two double telescopes giving magnification of ×15 and ×30. A record of the air temperature and weather conditions during the test can be made by thermographs and other instruments available.

RADIO-ASTRONOMY FOR AMATEURS*

The Journal of the British Astronomical Association for October 1956, vol. 8, p. 66, contains a paper with the above title by Dr Martin Ryle, F.R.S., of the Cavendish Laboratory, Cambridge. There is undoubtedly work that amateurs could undertake; nevertheless, many difficulties arise which are not found in the case of optical observations. Chief amongst these is the absence of data on the design of suitable apparatus, and it is suggested that plans for amateur work in radio-astronomy should be made in conjunction with the Radio Society of Great Britain. Next, there is the question of the expense, which would be too great for individuals; but this might be overcome by the formation of a local group to plan a joint instrument in co-operation with the local Radio Society. Programmes of investigations can be divided into two classes: (*i*) those which are of fundamental value to the astronomical world and which cannot or will not be done at the large observatories; (*ii*) those which, though they have no absolute importance because similar work is already being maintained at established observatories, are nevertheless of great interest.

Under (*ii*) are included observations of the enhanced

* As we go to press, we hear that the British Astronomical Association has formed a section to deal with the problems of Radio-Astronomy and electronic devices which could be used by the amateur astronomer. The first director of the section is J. Heywood, F.R.A.S., an assistant lecturer in telecommunications at a London technical college.

metre-wave radiation associated with solar activity, and such observations can be made with quite small aerials and without extreme receiver sensitivity. During the coming years of high sunspot activity an impressive series of records may be expected to be obtained at a wave-length of about 1·5 m., and such a programme would fit in well with simultaneous optical observations of sunspots. A watch of the more violent disturbances associated with solar flares and prominence activity might be of interest to the radio amateur in connexion with ionospheric disturbances and also long-distance radio propagation. Those with greater ambitions and sufficient space might engage in accurate positional observations of the sunspot sources, using an interferometer of, say, 100–150 λ aperture. One drawback is that the use of two aerials separated along an east-west line by a distance of about 250 yards would limit the number of amateurs wishing to undertake this programme, but, of course, this handicap would not be general.

A type of work requiring comparatively simple apparatus is the study of "seeing". Radio stars occasionally show rapid fluctuations of the intensity in the longer wave-lengths of about 3–10 m., the effect being produced by scattering of the waves by irregularities in the outermost parts of the ionosphere, at heights of about 450 km. Although observations have been made in different parts of the world, it is pointed out that the extension of this work is well suited to amateur observers, and England and Scotland are large enough to have a fair chance of establishing the area and possibly the shape of the regions of the ionosphere which are disturbed. Simultaneous and regular records over a wide area might give a much better picture of the build-up and decay of this effect. This is a difficult programme, involving not only the construction of a large number of sensitive sets, but also problems of organisation and reduction of observations.

It is suggested that the radio emissions from Jupiter be studied. Up to the present the radiation has been observed only on long wave-lengths of 12–18 m., where there is considerable trouble from radio stations and also from atmospherics. As this is a difficult problem, it is doubtful whether amateurs will undertake this work, at least in the near future.

The paper mentions technical problems that must be overcome: these include the use of frequencies clear of other transmissions; location; apparatus, etc. If there is sufficient interest among amateur astronomers, it might be possible to form a small technical group to study the problems mentioned. Dr Ryle promised to provide such groups with details of any of the apparatus at the Cavendish Laboratory, but could not undertake to answer inquiries from *individual members*.

RAIN-MAKING IN JAPAN

A recent report from Japan* announces the results of extensive trials to increase the rainfall over the mountains by artificial means. It is claimed that these have been almost invariably successful. The usual method is to produce silver iodide nuclei from smoke-generators, preferably placed on high ground. The minute particles of silver iodide have strong ice-nucleating properties, and as they diffuse into the upper atmosphere they are calculated to increase the local rainfall if the atmosphere is void of ice nuclei but otherwise in a condition to give rain.

Smoke-generators have been placed near the summit of Fujiyama, 12,390 feet. This peak is isolated from its neighbours, and changes in cloud structure can be observed from a number of weather stations situated around the foot of the mountain. It is also within range of radar screens in the Tokyo area.

In one zone, cloud-seeding is claimed to have increased the rainfall by 13%. The various districts of Japan are carrying out their seeding independently, but all claim successful results over the past two years. In Kansai province the initial success was so encouraging, and so many generators have now been installed, that it is difficult to assess present results owing to the lack of control areas where no cloud-seeding has taken place.

The report does not give details of the tests applied to determine whether there exists conclusive proof in increased rainfall by seeding. In view of the British Meteorological Office opinion that even if the increase of rainfall was substantial, some years of tests would be required to confirm it, these early results should be treated with reserve.

The Japanese experimenters have, however, given equal attention to theoretical and practical difficulties. They have measured raindrop size distribution, and have examined 115 different substances—from nickel oxide and mercuric chloride to urea—for ice-nucleating properties. They have found it possible to retard the deactivation of the silver iodide by spraying it with water vapour, ammonia, or hydrogen sulphide.

Above the southern island of Kyushu, ice pellets have been dropped from aircraft on to the tops of clouds. They invariably deformed the cloud, but rain fell on only half these occasions. From this island comes the one discordant note in the report: that silver iodide from smoke-generators decreased the rainfall in summer.

AEONS AND ECCENTRICITIES

When the Editor of DISCOVERY visited Switzerland recently, he found that Swiss scientists were contrasting their own extreme efficiency in the laboratory, and the almost regimented order of their daily life, with what they called "English eccentricity"; and they remarked that there seemed to be some strange virtue in the eccentricity itself, because it did produce ideas and thus results.

We had reason to recall these remarks when we attended the opening of the Aeon Laboratories at Beech Hill, Englefield Green, Egham, Surrey, where an electron microscope and all ancillary equipment has been set up in a beautiful country-house, surrounded by daffodils and beech woods, with a view across to Windsor Castle. This is not to suggest that there was any sign at Beech Hill of inefficiency: on the contrary, the rooms gleamed

* Halakeyama, H., "Report of Rain-making in Japan", *Papers in Meteorology and Geophysics*, vol. VII, No. 3, pp. 327–46, October 1956, published by Meteorological Research Institute, Toyko.

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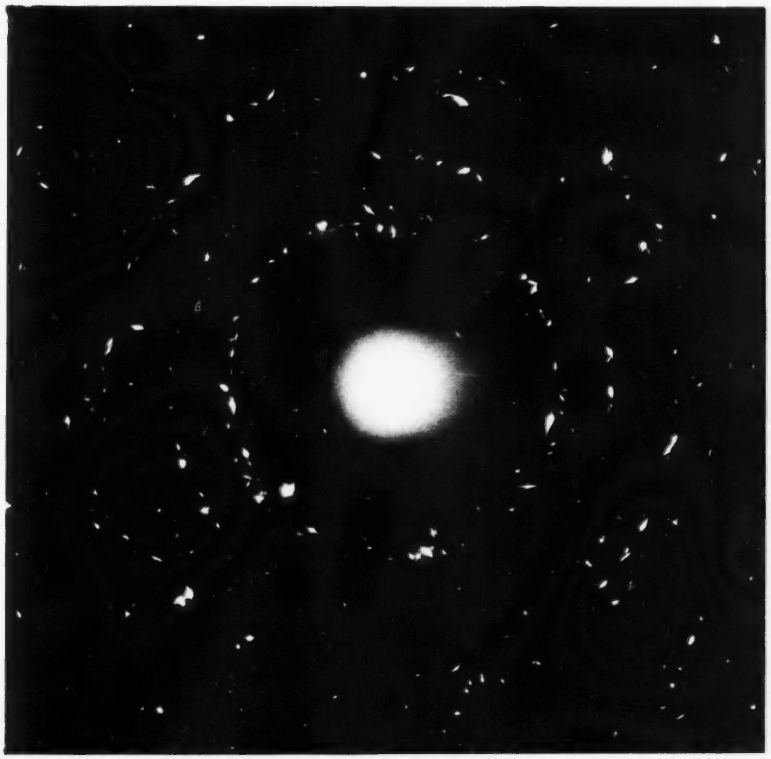
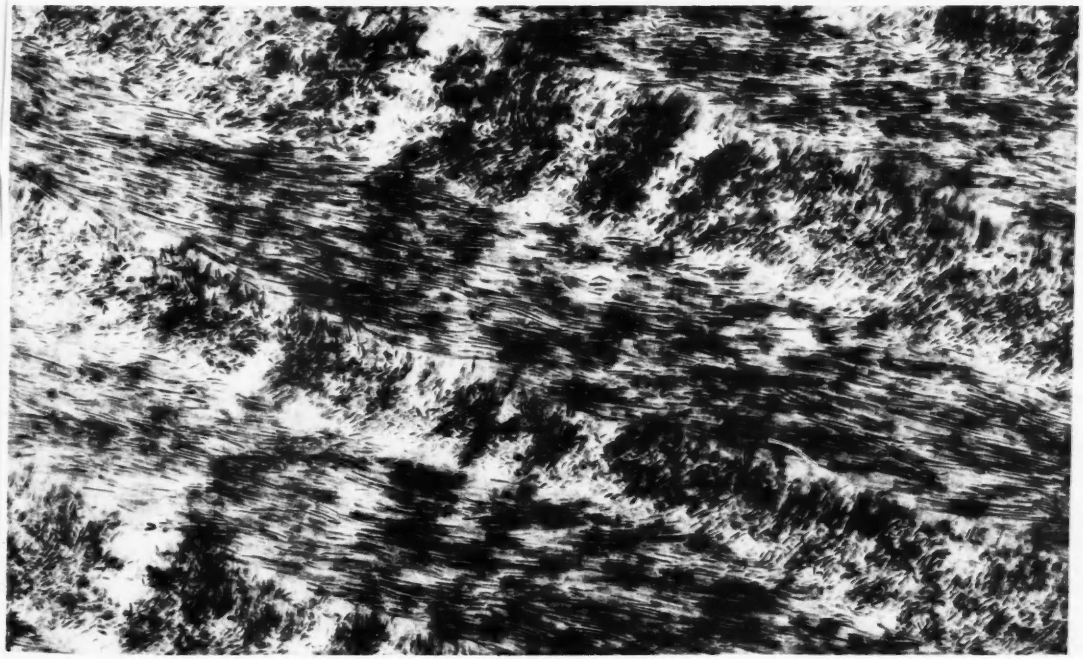


Right: Diffraction pattern from zinc oxide. *Below:* Enamel matrix from a rat-molar, magnification × 30,000. (*With acknowledgement to Mr F. W. Fearnhead of London Hospital Medical College.*) Both these photographs were taken with the aid of the Siemens Elmiskop I electron-microscope at Aeon Laboratories.



with whiteness and order. But side by side with the almost medical antisepsis there was a friendliness in the small rooms and unmilitary corridors which one felt sure must be conducive to good intellectual work.

The Aeon Laboratories have been founded primarily to provide a specialist service in electron and optical microscopy, for research workers in universities, research associations, and industrial laboratories. The other functions of the Aeon Laboratories are to train scientists in the operation and maintenance of the electron microscope, and in the various specialised specimen techniques which are an adjunct to electron and optical microscopy. To further these aims the laboratories are equipped with a Siemens electron microscope, a wide range of optical microscopes, the ancillary equipment required for specimen preparation, a small workshop, and complete photographic facilities.

The staff of the Aeon Laboratories will gladly give advice on the possible applications of electron microscopy; to assist and guide the staff, the services of a consultant panel are also available. Scientists already having experience in electron microscopy and specimen-preparation techniques, but not having available in their own laboratories electron microscopes of high resolution, may make use of the laboratories, and the electron microscope can be made available on a daily basis for such work. Alternatively, for those laboratories where no electron microscope is available, and yet the occasional demand for high-resolution microscopy arises, the staff of the laboratories will be available to work in co-operation in the development of preparation techniques and the examination of specimens.

The Aeon Laboratories have been equipped during the past six months, and up to now approximately fifteen hundred electron micrographs, from a wide variety of specimens, have been obtained. A number of university science departments and research laboratories have already made use of the facilities available, and it is hoped that the laboratories will make their contribution in the advancement of science.

The formal opening was by Prof. G. W. Austin, Goldsmiths' Professor of Metallurgy in the University of Cambridge, who remarked on the appropriateness of the name, Aeon, and who aptly quoted Goethe, leaving it for his audience to put upon it their own interpretation and translation: *Immer strebe zum Ganzen, und kannst du selber kein Ganzes werden, als dienendes Glied schliess an ein Ganzes dich an.*

NIGHTMARE-THERAPY

"How did you dream?" a Guaymí-speaking Indian asks his neighbour. That's the way he says "Good morning".

"I did not have any," replies the neighbour. That is the equivalent for "I am well".

This customary way of greeting, long since firmly incorporated in the language, is deeply rooted in the basic concepts of life of the Valiente Indians of Panama, according to the first vocabulary and grammar of the Guaymí language just published by the Smithsonian Institution's Bureau of American Ethnology. It was written by Dr Ephraim S. Alphonse, for many years a Wesleyan Methodist minister among these Indians. The Guaymí language is spoken by several groups in western Panama, and was one of the basic tongues of the Caribbean area.

This linguistic curiosity, Dr Alphonse explains, is based on the Valiente Indians' extreme fear of dreams. When a person has an evil dream he feels sure he will die unless powerful magic is exerted. The psychological effect is so strong that the victim often does in fact die, in spite of anything that can be done for him. The term in the language for "bad dream" is "death struck him". It is believed that the only way to escape the effects of such a dream is through the mediation of a powerful medicine-man, the Sukya, who has influence to exorcise the evil spirit. A friend tells him the dream of the stricken victim and the Sukya may then be able to find a weed, plant, or bark that will be effective against the particular evil spirit responsible. After he has been paid an appropriate fee, the Sukya proclaims a wake, or "ngwote", for the dreamer's hut. As part of his fee, the Sukya receives some cocoa-beans, upon which he blows to sanctify them. They are then parched, ground, and made into a drink.

For five days and five nights neighbours and relatives gather at the dreamer's hut and drink this mixture, diluted until it is slighty more coloured than water. Nobody is allowed to sleep. By this means the evil spirit is kept away; and the soul of the sick person, which is presumed to have been taken away from him during the dream, is given a chance to return and so to enable the patient to recover. He sometimes does.

The wake is an elaborate affair. Crosses of balsa wood are set up on either side of the main roads leading to the hut, and a kind of vine is erected as an arch, under which the evil spirit must pass. In the middle of the arch is a noose, which presumably will catch the demon as he comes for his victim. A magic preparation made by the medicine-man is dropped into the eyes of the guests. In the hut are crosses. Balsa sticks are carved to represent human heads and faces made hideous with charcoal marks.

The person who has had the dream is put inside a fence built round a raised platform, on either side of which are placed two crosses. The fence is made of wild canes, of which the evil spirits are supposed to be afraid. During the ceremony the burning of wood-termite nests, a stink vine, and pepper causes heavy smoke, which fumigates the evil spirit.

The victim of the bad dream must abstain from certain foods, from any contact with certain persons, and from eating anything cooked on the fire with which these banned people cook. Consequently, two fires are built in the same hut, one for the victim and one for the rest of the household. The persons prohibited from contact are not necessarily enemies, and they may even be members of the man's own family. It is, for example, fatal for the patient to have contact with anybody who has ever been bitten by a snake.

VISION AND BEHAVIOUR

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The work mentioned briefly in this article, represents the first steps towards integrating the approach of the physiologist and the psychologist to the field of vision. Already these matters are receiving the most detailed attention from both groups. This leads on to a study of the biochemical properties of the eye and nervous tissue on one hand, and on the other, a mathematical theory of the visual system, by the use of communication theory and the like.

These are all steps towards the integration of science; the breaking down of the older artificial barriers between different parts of science and especially the development of Human Biology.

Everyone is extremely aware of the importance of the eye for the carrying of information about the external world to the brain. More than any other of our senses, the eye is catered for by enormous numbers of nerve cells. Much of our study of the central nervous system indeed involves a study of nervous tissue that is connected with the visual system.

The eye itself is one of two large receptor systems which receives messages transmitted from the outside world, by means of light waves, to the retina. The retina is the layer of nervous tissue that lies along the inner surface of the spheroidal body of the eye. The light which first impinges upon the hard protective surface of the cornea passes through the watery aqueous humour of the outer chamber of the eye, through the lens, through the jelly-like vitreous humour of the inner eye and then impinges upon the ten neural layers of cells that make up the retina.

We are not here concerned with the properties of geometrical optics that, according to the shape of the lens and the focal distance of the eyes, work together binocularly to give a detailed statement of the size of the image that is projected upon the retinal cells.

The retina being taken rather as the starting point, the impulses that are set up there are transmitted along the optic nerve fibres back to the occipital lobe of the brain, that lies at the back of the head. On the way back, half the fibres of the right eye cross over to the left side of the brain, and half the fibres from the left eye cross over to the right; the optic chiasma is where this crossing-over takes place. One other stopping place on the route back is at the lateral geniculate body, where connexions are made with the thalamus, and lower nervous centres. The rôle of the lateral geniculate body is probably that of a summater of impulses, since messages from the retina are being sent down the optic nerve, which forms a restriction; and thus, for the message to arrive intact at the occipital cortex, it must be reassembled somewhere at, or before, the other end.

The occipital cortex, known to be explicitly connected with visual functions, is not, of course, the end of the journey of such visual messages. They are transmitted through to all other parts of the brain, and involve memory, interpretation, executive action, and so on. This is the cause of much difficulty. It is difficult to separate those activities that we observe in ourselves that are purely sensory (that is, events which are purely the result of the visual system's activity) from those that are the result of a more complex process. We can make a rough distinction between the visual system (including area 17) and the rest of the cerebral cortex. But such a distinction can only be rough, since in practice such a wholehearted division is not possible. Experiments on constancy phenomena demonstrate the point.

The first distinction that we are able to make is between activity that is purely retinal and that which goes on at some higher centre. This is made possible by the fact that some of the fibres from the left eye cross over to the right cerebral hemisphere, and vice versa. This means that if we take some simple visual effect such as that of after-images, then we can decide quite easily whether we are dealing with something in the retina or not.

THE AFTER-IMAGE AND AFTER-EFFECTS

The after-image situation can be characterised quite easily. If a red light is projected on to an eye, then after the light is switched off and the person stares at a white card he will see the complementary colour of red, namely green. Now we can reasonably ask whether this is due to something taking place in the retina or somewhere behind the optic chiasma.

Let us carry out the experiment. Shine a red light into the right eye for about 30 seconds, and then look at a white card and see the green after-image. Now repeat the performance using the *other* eye to look at the white card after the half-minute with the first eye. If the effect is central (somewhere behind the chiasma), then the left eye should see the green patch even if the right eye was stimulated by the red flash. If it does not, then the implication is that it is something taking place in the retina itself.

In fact after-images are retinal, and are thought to be connected with the processes of chemical change in the retina. However, there is another effect which experimenters have noticed which is different. If you take a curved line and fixate some point at about the centre, you find that after a time the line seems less curved.

Let us state a more controlled example of this last effect. If you ask a subject to look at a small dot or fixation point on a card which has two large square line figures on either side of the fixation point, thus falling on the periphery of the eye, then after about a minute, if he is asked to look at another fixation point with two equal circles on either side of it, he will report that the circle on the same side of the fixation point as the larger square will appear smaller than the circle on the opposite side.

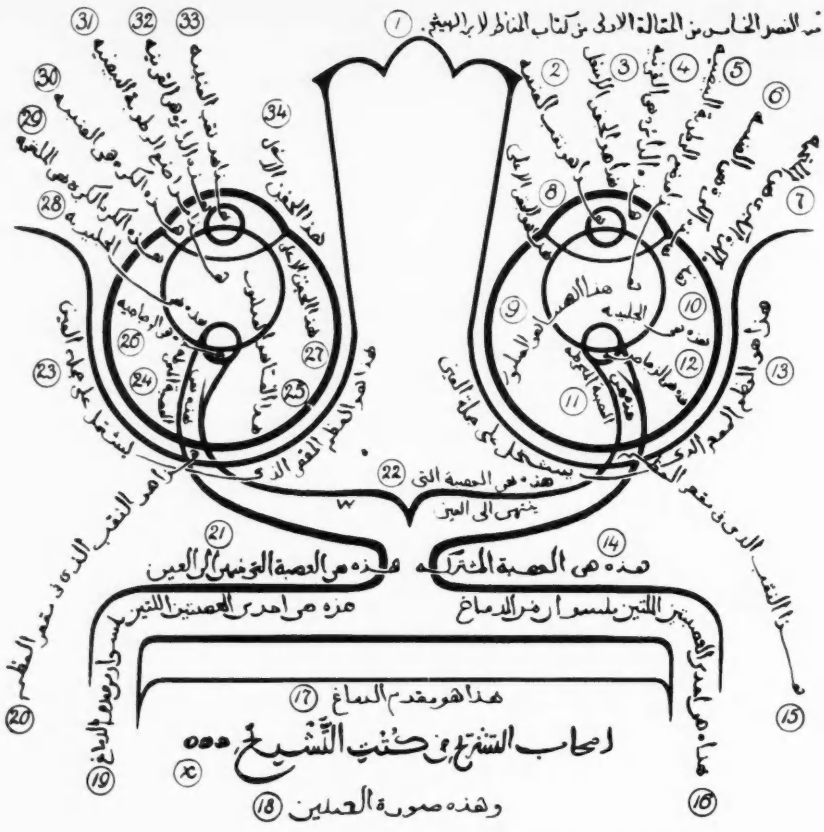

FIG. 1. ARABIC CONCEPTION OF HUMAN VISUAL SYSTEM.

Diagram illustrating the complete human visual system and its relationship to the brain. Copied, slightly reduced, and with slight changes, from the Arabic original of the Kitab al-manazir, or Book of Optics, by Ibn Al-Haitham, or Alhazen (A.D. 965–1039), now in the possession of the Fatih Library (Fatih Kitapsaray), as MS No. 3212, at Istanbul (Constantinople), Turkey. This book was rewritten by Ahmad ibn Muhammad ibn Ja'far, the author's son-in-law, in A.H. 476, or A.D. 1083, at Basra, Iraq. The book is the oldest preserved copy of Alhazen's Optics; and the figure, perhaps a copy from an older, probably originally a Greek diagram, is the oldest extant pictorial representation of the visual system, or the nervous system in general.

Labelling: (1) "From the fifth chapter of the first book of the Book of Optics by Ibn al-Haitham", a remark made by the modern librarian and not found in the original; (2 and 33) "this is the hole of the uvea", sc., iris, that is, the pupil (hadha huwa thaqb al-'inabiyya); (3 and 34) "this is the lower lid" (hadha huwa al-jafn al-asfal); (4) "this circle is the cornea" (hadhihi al-da'ira wa-hiya al-qarniyya); (5 and 31) "this is the place of the albuminoid humor", that is, aqueous (hadha mawdi' al-rutuba al-baidiyya); (6 and 30) "this sphere is the uvea", that is, the iris (hadhihi al-kurra al-kubra hiya al-'multahima); (7 and 29) "this large sphere is the conjunctiva" (hadhihi al-kurra al-kubra hiya al-multahima); (8) "This is the upper lid" (hadha huwa al-jafn al-a'la); (9 and 25) "this membrane is the spider", that is, the arachnoid or the anterior capsule of the lens (hadha al-ghisha huwa al-'ankabut, instead of al-'ankabutiyya, or arachnoid (compare 7 and 9); (10) "this is the icelike", sc., humor, that is, the crystalline lens (hadha hiya al-jalidiyya); (11 and 24) "this is the curved nerve", that is, the optic nerve (hadhihi hiya al-'asaba al-munkharifa); (12 and 26) "this is the glasslike", sc., humor, that is, the vitreous (hadha hiya al zajajiyya); (13 and 23) "this is the hollow bone (orbit) which includes (or surrounds) the whole of the eye", that is, the eyeball (hadha huwa al-'azm al-muqa"ar alladhi yashtamil'ala jumlat al-'ain); (14) "this is the joining (associating) nerve", that is, the chiasma (hadha hiya al-'asaba al-mushtarika); (15 and 20) "this is the hole which is in the hollow of the bone", sc., of the orbit, that is, the optic foramen (hadha al-thaqb alladhi fi muqa"ar al-'azm); (16) "this is one of the two nerves which originate from the brain" (hadha ahda min al-'asabatain yanbitan min al-dimagh); (17) "this is the anterior portion of the brain" (hadha huwa muqaddam al-dimagh); (18) "and this is the figure of both eyes", a remark which, with the line (x) belongs to the text; (19) "this is one of the two nerves which arise from the anterior portion of the brain" (hadha hiya ahda al-'asabatain allatain yanbitan min muqaddam al-dimagh); (20) similar to (15) (hadha huwa al-thaqb alladhi fi muqa"ar al-'azm); (21) "this is the nerve which terminates in the eye" (hadhihi hiya al-'asaba allati tantahi ila al-'ain); (22) same as (21); (23) same as (13); (24) same as (11); (25) same as (9); (26) same as (12); (27) similar to (8) (hadha al-jafn al-a la; (28) "this is the icelike", sc., humor, that is, the crystalline lens (hadhihi hiya al-jalidiyya); (29) same as (7); (30) same as (6); (31) same as (5); (32) "this circle is the cornea" (hadhihi al-da'ira hiya al-qarniyya); (33) same as (2); (34) same as (3) "this is the lower lid" (hadha al-jafn al-asfal); (x) "the anatomists in the books of anatomy", a remark which does not belong to the legend of the figure.

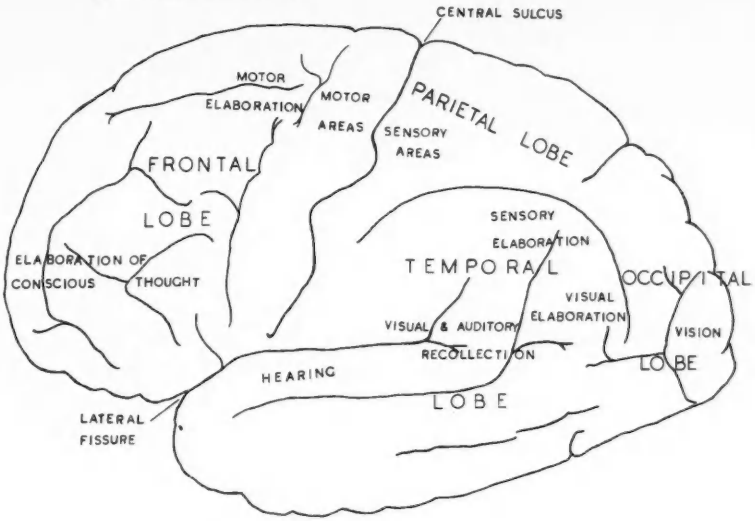

FIG. 2. Diagram of the brain showing the visual and other areas of the cortex.

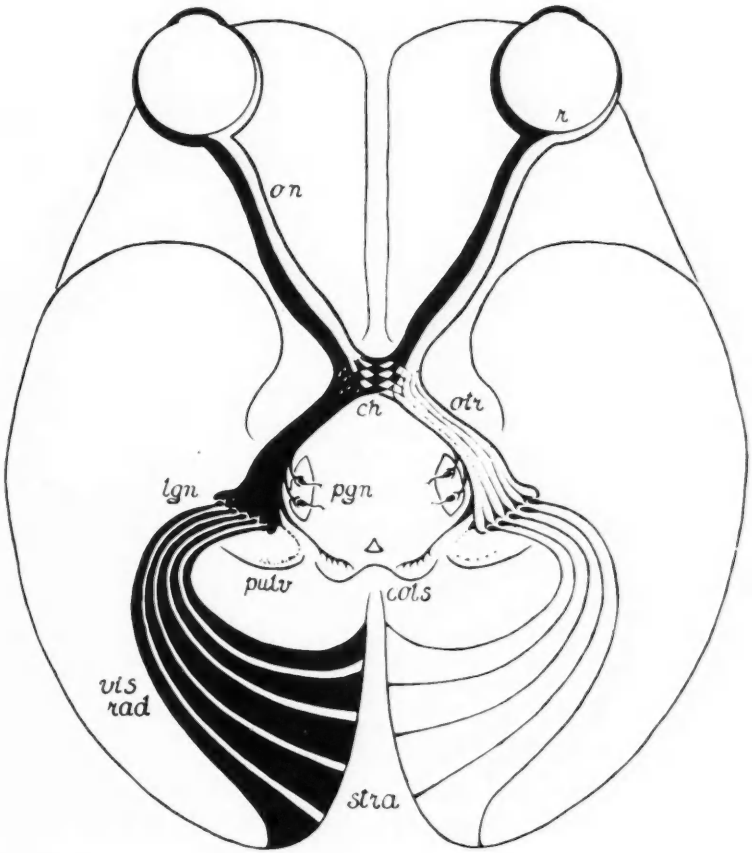

FIG. 3. Diagram of the visual system in Primates (Monkey, Ape, Man) drawn in the outline of the human brain. Two-thirds natural size. The infranuclear division is composed of the eyes, or eyeballs, each enclosing the retina (*r*), of the optic nerves (*on*), and of the optic tracts (*otr*), connected by means of the optic chiasma (*ch*). This division terminates in the subcortical visual centres, of which the principal one is the lateral geniculate nucleus, or lateral geniculate body (*lgn*); the others—the pregeniculate nucleus, or *griseum praegeniculatum* (*pgn*), and the superior colliculus of the midbrain (*cols*)—are subsidiary. A fourth, and a less probable, subcortical visual centre is the pulvinar of the thalamus (*pulv*). The supranuclear division of the visual system is represented by the visual radiation (*vis rad*), a fibre tract originating in the lateral geniculate nucleus of the midbrain (*lgn*) and terminating in a portion of the superficial grey matter or cortex of the occipital lobes of the cerebrum, called "striate area" (*stra*). In the chiasma (*ch*) the nasal or inner halves of the optic nerve fibres, originating in the nasal halves of the two retinae, intercross. In consequence, while each optic nerve (*on*) represents the retina of its own eye, in the visual pathway from the chiasma to the cortical visual centres (*otr*, *lgn*, *vis rad*, *stra*) each side, right and left, represents the ipsilateral or homonymous halves of both retinae.

In the above experiment it is best to take the centres of the circles and the squares at the same point. This means you will start with three points; one in the centre of the card to fixate, and two on either side as centres of the squares and circles respectively. What is the cause of this distortion? Before we attempt to answer this question, we can show at any rate that it is a central effect of some sort, because if you use the right eye to fixate the card with the squares, then even if you use the right eye to test the effect on the circles the distortion will still occur.

The actual effect which is called the "figural after-effect" is not wholly understood, but at least it is thought to be due to changes taking place in the area 17 of the occipital lobe. The model of the visual system which it has been suggested fits these facts fairly well, takes the following form.

There are cells in the retina that fire with a change of stimulus conditions. These are called on-off fibres. There are other cells that fire for off-states only, and others that maintain a rate of firing during the whole period of stimulation. These fibres, with their various complications of connexions, seems to make up two sorts of visual function, what Sir Henry Head called epicritic and protopathic: the careful visual discrimination that makes up visual acuity, and the grosser changes of general illumination and movement respectively.

To some extent the two systems follow the distinction between predominantly cone and predominantly rod areas of the retina. The retinal cells fire at a contour line, where black grades over into white, for example (we do not need to include the purely retinal and probably biochemical effects associated with colour discrimination), and this rather complex firing of the retinal cells, aided as it is by movements in the eyes, is transmitted back to the area 17. In area 17, there is something approaching a reproduction of the state of affairs of the retina, and the recording of a contour line as "having been seen" will coincide with the maximum of excitation of the retinal cells as represented there.

If this over-simplified picture is nearly correct, there will be an interaction between the lines that make up the circles and the squares in the figures described above, so that the lines of the squares which can be thought of as superimposed on the circle and circumscribed about it, will displace, by a squashing effect, the circle, and the opposite will happen with the other circle. This will be enough to account for the disparity in the size and this is known as the figural after-effect.

Now the above effect is certainly incidental to the structure of the visual system; it was not part of what the system was designed to do. Any system it will be appreciated may be intended (we use this word here only for the sake of clarity of explanation) to do one set of things, but happens as a result, to have incidental properties of perhaps an unforeseen kind.

The eye is obviously intended to discriminate different coloured patches in its environment. This involves, apart from the colour, the ability to discriminate small differences in brightness. The actual power of such discrimination clearly varying with the illumination, the relative size of the areas concerned, the previous stimulation, and so on. The eye is divisible into the parts which are primarily to record statical detail, and into parts which record changes of position and movement—that is, dynamic detail.

The figural after-effect, as well as after-images, and other properties of the eye, such as the effect known as "contrast", where black appears blacker if on a white background, are almost certainly incidental properties. The great importance of such incidental properties for physiologists and psychologists who are studying vision, lies in the fact that we can study these phenomena with the idea of throwing light on the general ("intended") properties of the system.

BINOCULAR VISION

There are further complications in the visual system due to the fact that two eyes work together to give what is called binocular vision: this permits greater depth perception, and allows us to perceive the 3-dimensional nature of our immediate surroundings.

Now let us suppose we sufficiently understand the eye as a sort of super-camera, like a television scanning mechanism that is capable of scanning the environment and recording what goes on there. The light is controlled reflexly by alteration in size of the iris diaphragm, and the eye records different shapes and colour which it transmits to the brain. There are further problems, many of them about the exact nature of this transmission, but in essence the process is understood. We should perhaps cite one example of a problem that poses some difficulties for explanation and yet is almost certainly an example of what we have called an incidental property. If an object moves in the environment and the eyes fixate a point near to this movement, then when the movement stops, there is an impression of movement in the opposite direction.

This last effect is quite common, and it will often have been noticed, when one is sitting in a train, that when the train stops it appears for a while to be going in the opposite direction. These are sometimes referred to as "movement after-effects".

These movement after-effects might be explained in the same sort of manner as the figural after-effect, especially if there were two different components operating—one to give the ordinary displacement effect characteristic of the figural after-effect, the other a prolonged after-movement of the eyes—perhaps associated with eye-movements or with the biochemistry of the eye. But largely this is a question that still requires to be settled, although its solution almost certainly lies in the same direction as the ones that have already been discussed.

THE NATURE OF SEEING

Now a real difficulty arises. We have been discussing visual effect as if they were entirely independent of the controlling function of the brain, and the storage system, which is the basis of what we commonly call memory. This is obviously not really the case. For this very reason there is difficulty in deciding what we mean by

"seeing" or "perceiving". The difficulty can be put this way. To what extent are some of the effects we get the result of our previous experience, and interpretation in the light of this experience, and to what extent are they not? An example will be helpful. Consider an example of what is called a "constancy phenomenon". We see a piece of coal lying on the floor and we can say that we *see* or *perceive* it as black even though it is not really black to us at that moment.

Let us consider the example a little further. If we are asked to look at the surface of the coal through a tube that shows us so little of the coal that we do not *recognise* what the surface is, we see it as bright greyish, and not black at all, if it is enshrouded in a bright light where the light source is not visible. As soon as we see enough of the surface to recognise the object as a piece of coal, however, we *see* it as black. This seems to be the result of having a definite idea of what the colours of certain objects are, under some standard conditions of illumination. If they look different from this standard, it is assumed to be on account of differences in local conditions. This is precisely an example of how our memories, and our generalisations about the world, influence what we *see*. This influencing probably takes place at cortical levels, and there is a two-way system or relationship between the visual cortex and the visual system on one hand and the rest of the cortex on the other. When we expect to see something, or somebody, we are more prone to see it, or them, than something else or other people we are not expecting to see. This is almost certainly due to the controlling cortex's direct influence on the visual system.

The explanation of this close and rather complicated relationship between the sensory systems and the controlling central systems is dependent on the fact that in perception, we *interpret* certain simple visual patterns. We actually identify objects, people, and the like, by only a tiny part of them, coupled with the context in which they occur. The piece of white screwed-up paper on the floor may be seen as a mouse if we are expecting to see a mouse when we walk into the kitchen. Immediately we are persuaded by other considerations that our first impression, as we call it, was incorrect, although this will not always be the case.

There are some interesting examples in the perceiving of movement that show that quite complicated apparent movements are recorded by the eye when different patches are illuminated in quick succession. This is repeating under identical conditions the actual state of movement, and the eye will often be deceived into thinking there is an actual movement when there is not. The central controlling cortex's influence on these proceedings is brought out when we see that if the visual effect of apparent movement, as demonstrated by two close positioned light-sources flashing in turn, are accompanied by a clicking phenomenon; this occasions what is called the "pendulum effect". It is merely that the interpretation on the situation as a whole influences the way the apparent movement is *seen*.

It is indeed obvious that one of the complications that occur in the normal organism is the fact that information from various sensory sources will interact, and it is difficult if not impossible in practice to study merely one sensory system such as the visual system.

There is one further question suggested by all that has been said, and that is whether or not the effect of the memory store, or the preconceptions held by the organism, directly change the state of the threshold in the visual system, or whether the visual system simply records the stimuli that are given, and the interpretation of its record is given by the controlling cortical tissue. This raises further problems.

One of the points of this article has been to show how difficult it is to study the behavioural responses of the visual system alone. Even when you ask a subject in an experiment what he "sees" there is an unavoidable ambiguity about the question, because he is not, as far as we can tell, capable of distinguishing between what he *sees* and what he *believes* to be the actual state of affairs, where he has clues and cues about the actual state of affairs—or to put it another way, where the situation has a familiar meaning, and the process of recognition is involved. When unfamiliar material is used to try and offset this effect the result is only partially successful, if only because, by using unfamiliar material, we are tending to study the visual system acting in atypical circumstances. It is for this reason that we have made such detailed studies of artefactual aspects of the visual system, such as figural after-effects.

Finally the whole problem of understanding vision, or any other sensory modality, can be seen to be fraught with difficulty, especially when this is attempted from the viewpoint of the understanding of the behaviour of the organism as a whole. The physiological work on the structure of the visual system is not altogether free of these dangers but is less prone to them when concentration is on matters of structure and function of the visual system, where inferences are not dependent on introspective statements by a human subject.

The visual system is clearly part of the classificatory mechanism of the organism, and we may guess that the understanding of the way the visual system works can never be wholly understood other than in terms of the behaviour of the organism as a whole, and this may require that we pursue more naturalistic experiments on the organism, which will show us how visual activities modify general behaviour patterns by simple neural changes in the visual system alone.

RESEARCH IN INDUSTRY: RADIO

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We live in an age when it has become fashionable for public speakers to pay tribute to the contribution which scientific research makes to the development of industry. It would be wrong for an industrial scientist, such as myself, to doubt the sincerity of such tributes, although there often appears to be lingering doubts in the speaker's mind, a suspicion that scientific discovery is a mixed blessing, not only for industry but for mankind in general. I note in these speeches a tendency, moreover, to stress only the material aspect of the scientific contribution and to neglect completely the impact of scientific thought on man's attitude to life and to his fellows; but the modern world is a product of the technology which has sprung from scientific research, and at a time when international affairs are dominated by the threat of atomic weapons there can be no doubt about the influence of scientific work upon our daily lives.

Of all the examples we might take to reveal the full extent of the part played by scientific research in shaping industry and affecting thereby the minds and lives of men, none can make the point more effectively than the development of the radio industry. Radio supplies the communication service which is so essential to the modern world, and in meeting this need it has become an industry in its own right. Industry, commerce, travel by sea and air, and military operations of all kinds are alike increasingly dependent on this industry, which is thus affecting our lives in a material or physical way. More obvious still is the mental influence on mankind of radio broadcasting, both sound and television. From radio has sprung the subject of electronics which, through its application to automation, is presenting the world with a second industrial and social revolution.

EARLY RESEARCH

This radio industry, which is of such importance in the modern world, is the direct outcome of pure scientific research and continues to draw its vigour from pure and applied research. This is apparent from even a cursory survey of the development of the subject, for it was Faraday himself who reacted against the action-at-a-distance theories used to explain the electric and magnetic phenomena known in his day, and who built up a formidable body of experimental evidence to support his view that the medium surrounding the electric and magnetic elements was the true seat of electromagnetic energy. It was these researches of Faraday that led to the field concepts which, in the hands of Maxwell, resulted in the famous field equations of 1864 and the Electro-Magnetic Theory of Light. This daring, yet attractively simple theory of travelling electric and magnetic fields was triumphantly verified by Hertz in 1888, who showed that an electrically oscillating circuit could launch an electromagnetic disturbance that behaved in all essential respects as would a light-wave. This experiment opened up a new branch of physics, but it was Marconi's work in adapting the experiments of the physicists and adding his own essential contribution of the tuned aerial in 1897 that established a commercially feasible system of radio communication and so created the radio industry.

If it is true that the basis of the radio industry is to be found in the field theories of the physicists and the demonstration of radiation and propagation of electromagnetic waves that resulted from them, it is equally true that the spectacular development of the industry derives from the invention of the thermionic valve by Sir Ambrose Fleming (diode, 1904) and Lee de Forest (triode, 1906), who based their work on the pure researches of scientists such as Sir J. J. Thompson and R. A. Millikan on the electron.

The indebtedness of radio engineering to pure scientific research could be illustrated by examples taken from every phase of its development and overall aspects of radio, such as the dependence of television on the experiments on the photo-electric effect which originally led to that early triumph of the quantum theory—the Einstein Equation. But the purpose of this article is to show that this dependence of radio progress on scientific research is just as marked today as in the past, and so we will draw our illustrations from contemporary studies that are establishing the radio industry of the future.

HARTLEY'S LAW

The general trend of radio development has been in the direction of higher frequency and greater power. This tendency is in accordance with Hartley's Law, which relates the rate of information transfer over a radio circuit, I, to the band-width, W, and the signal-to-noise ratio (S/N) by the expression

$$I = W \log \left(1 + \frac{S}{N}\right).$$

By the use of higher carrier frequencies, it is possible to increase the band-width of the transmission and so the rate of information transfer. The economic utility of the circuit is correspondingly improved. Similarly, improvement in I results from use of greater power, for in this way the value of the signal-to-noise ratio S/N is increased. This general movement towards the use of higher frequencies and greater powers is best illustrated by reference to the changes brought about during the war years. Immediately before the last war, broadcasting and communication services were confined to frequencies below 30 Mc/s. The first British radar chain of 1937 was set up in the 20–30 Mc/s band and utilised pulse powers in the order of 100 kW. The communication services of the Royal Air Force at that time were confined wholly to the high-frequency band. In contrast to this state of affairs, it is impressive to note that by the end of the war the intensive research which had been

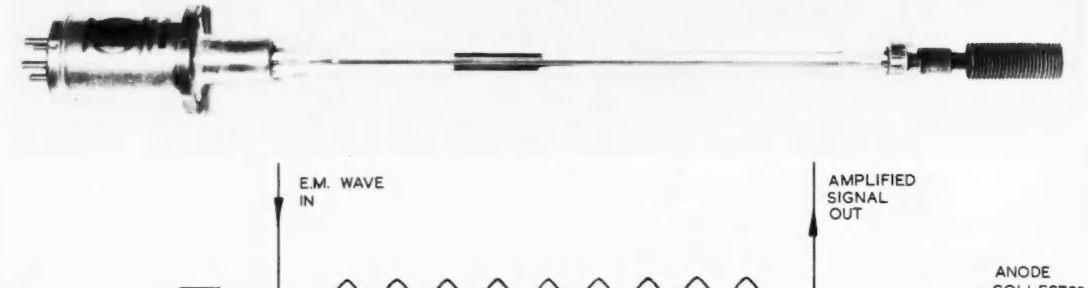

FIG. 1. Photograph of a 20-watt Travelling-wave tube for 2000 Mc/s. Diagram below.

applied to microwave generation and transmission had resulted in completely new radio-frequency generators such as the magnetron and the klystron, which permitted the design of radars on frequencies up to 30,000 Mc/s. Similarly, spectacular increases in power were also achieved over this period, particularly in the preferred 10 cm. band, or 3000 Mc/s, where pulse powers of 500 kW were commonly employed. Fighter aircraft communications and direction-finding systems had likewise risen in frequency to 150 Mc/s, and one point-to-point Army set was even operating at a frequency of 5000 Mc/s.

This trend in radio engineering has continued since the war, and results from the application of new principles to the conversion to A.C. form of the D.C. energy associated with an electron beam in a vacuum tube.

Conventional valves achieve amplification of radio signals by impressing the signal voltage on a grid so placed in the electron stream emitted from a thermionic cathode that control is obtained of the number of electrons arriving at an anode located in the same envelope.

If the frequency of the signal to be amplified lies in the microwave band, the above simple valve action no longer operates since the time required for one cycle of the applied radio frequency signal is comparable with the time taken by the electron to travel from the cathode to the anode. New methods of amplification and radio-frequency generation were therefore looked for, and resulted in the velocity modulation principle which is used in the magnetron and the klystron.

TRAVELLING-WAVE TUBE

In the newest form of microwave power source, the travelling-wave tube (Fig. 1) which was invented by R. Kompfner in 1944,* the electron beam is fired along the axis of a helix contained in an evacuated glass tube. The microwave signal to be amplified is applied to one end of the helix and is subsequently guided along the helix whose coiled form reduces its velocity parallel to the electron beam by a factor related to the pitch of the helix. In this way the velocity of the wave may be matched to the linear velocity of the electrons in the beam. Under these circumstances the kinetic energy of the electrons may be abstracted from the beam and transferred to the electric wave travelling along the helix so that its amplitude is increased; in other words, the tube is an amplifier of microwave signals. This action, moreover, is essentially a broad-band one, and therein lies the particular usefulness of the travelling-wave tube.

Travelling-wave tube amplifiers and oscillators of the helix type, and also in forms utilising other slow-wave structures, have been produced for frequencies of 1500 Mc/s up to 10,000 Mc/s, and research is in progress in many laboratories today to produce such tubes operating at frequencies in the band 50,000 to 100,000 Mc/s. Tubes of this type are finding application in the microwave point-to-point communication systems which, in the near future, are likely to provide trunk telephone circuits in areas such as East Africa, comparable in extent and complexity with the line systems of the developed countries of Europe and North America. In these systems the signals from as many as 600 telephone subscribers are channelled and shifted in frequency so that they can be impressed as frequency modulation on a microwave carrier. After final amplification in a travelling-wave tube, the signal is radiated from a dish or horn aerial, and is collected by a similar aerial 30 or 40 miles away, associated with a repeater station. The attenuated signal which is received at the repeater is first amplified in a low-noise travelling-wave tube, and after a slight frequency shift (introduced in order to avoid undesirable feedback) it is amplified by

a power travelling-wave tube for onward re-transmission to the next repeater. In this way about eight hops can be achieved before the quality of the signal is in any way impaired.

Fig. 2 shows such a repeater station improvised on a water tower during relaying of 4000 Mc/s signals which carried radar and television pictures of the aircraft operations at London Airport to a remote display set up at Farnborough for the SBAC Show of September 1956. The inclined metal mirror reflects the signal into the receiver dish lying horizontally on the roof of the vehicle in which the repeater is housed. A similar arrangement at the other side of the tower launches the amplified signal on to its next hop.

TROPOSPHERIC SCATTER

In the klystron generator mentioned above, use is made of the velocity modulation principle to achieve 10,000-fold amplification of microwave signals. In Fig. 3 is shown a power klystron capable of delivering an output of 10 kW at a frequency of 1000 Mc/s for use in the newest mode of communication known as Tropospheric Scatter. In this system, over-the-horizon propagation of microwaves is obtained by scattering from discontinuities in the refractive index in that part of the atmosphere which constitutes the troposphere. This scattering process is extremely inefficient, but by the use of high-power klystron generators, coupled with aerials of high directivity and gain, that is, having wide apertures, it is proving possible to maintain steady communication over distances of 200–300 miles, free from the vagaries which have marred the high-frequency radio circuits in the past. This new tropospheric scatter mode is also applicable in geographic situations where it is impossible to use the type of microwave point-to-point system described above. This latest addition to communication technique has been made possible only by intensive research on the propagation of microwaves through the atmosphere. So far, it has been applied in this country only to an experimental circuit, one terminal of which is shown in Fig. 4, which clearly shows the large aperture plastic antenna employed; but there is little doubt that tropospheric scatter will find extensive use, and its comparatively wide band-width should make it especially useful for television and multichannel telephone transmission from isolated territories, for example, when it is necessary to span stretches of water, desert, or jungle.

FIG. 2. Repeater station for 4000 Mc/s microwave link, using a passive reflector.

FERRITE UNILINE

The economic need for accommodating a large number of telephone channels in a microwave trunk communication system brings with it certain special problems associated with the linearity of the transmission process, and the need to fulfil the conditions for faithful transmission of signals has caused the study of the microwave transmission properties of ferrites to be actively pursued.

When a large number of telephone signals are simultaneously impressed upon a microwave carrier, as in the system described above, it is necessary that there shall

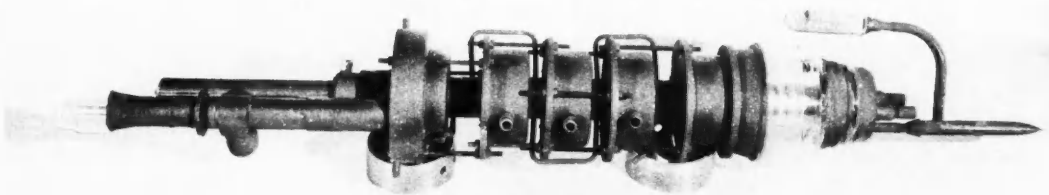

FIG. 3. 10-kW Multi-cavity klystron for 1000 Mc/s.

FIG. 4. Terminal of experimental 1000 Mc/s tropospheric link, showing feed into a 30-ft. plastic paraboloid.

be no cross-talk or interaction between the individual channels. Any departure from linearity in the transmission system will produce such cross-talk, and even the ordinary process of feeding a parabolic dish aerial from a horn and wave-guide carrying the microwave signal may introduce this undesired effect, unless back reflections into the wave-guide can be avoided. It is now proving possible to overcome this reflection effect by using certain properties of ferrites which have only been revealed by researches over the last few years.

When a piece of ferrite—for example, magnesium manganese ferrite—is suitably located in a short length of rectangular wave-guide, then if the ferrite is polarised by a permanent magnet placed outside the guide it is found that an electromagnetic wave passing through the guide is attenuated for one direction of transmission and unaffected when the direction of transmission is reversed. Such a ferrite contains magnetic elements that have a magnetic moment and an angular momentum associated with each of them. In other words, the active constituent in the ferrite is the assembly of electron spins. The couple exerted by the applied magnetic field upon the magnetic moment causes the spin to precess at the Larmor frequency about the field, just as the torque exerted by gravity upon a spinning top produces precession about the earth's gravitational field. If the ferrite is now subjected to a radio-frequency magnetic field rotating in the same sense as the Larmor precession, energy will be fed into the electron system, this absorbed energy being dissipated as heat, whereas no absorption will occur when the sense of rotation is opposite. In a device using this effect the ferrite is positioned in the wave-guide where the magnetic field associated with the wave being propagated in the guide is rotating, the rotation being in opposite senses according to the direction of propagation. Thus in one direction —outwards from the generator—there is free passage to the wave, in the other, absorption, and the amount of wave attenuation can be made quite high relative to the forward loss by the use of specially prepared ferrites.

Such a microwave circuit element is called a Uniline. Fig. 5 illustrates a resonance-type uniline designed for a frequency of 2000 Mc/s ($\lambda = 15$ cms.), which can give a forward loss of 20 dbs., with a reverse loss of only 0·8 dbs. A line of this type will substantially eliminate all the wave-guide reflections in the wave-guides of a microwave communication system and so increases the channel-carrying capacity of the system.

The same fundamental effect gives rise to other microwave properties of ferrites which are being closely studied at the present time, such as the Faraday gyromagnetic effect where non-reciprocity in microwave transmission in a cylindrical wave-guide again results from interaction of the electron spins with the travelling magnetic field component of the electromagnetic wave in the presence of the static magnetic field.

This interaction causes rotation of the plane of polarisation of the wave and permits uniline elements to be constructed using the cross-polarisation principle, somewhat as a Nicol prism is used in optics to reject a wave of light polarised perpendicular to the acceptance axis of the Nicol.

Ferrites are finding application in microwave systems in other ways, but it is a fascinating thought that such applications depend ultimately upon the principle of the interaction of the individual electron spins in the ferrite with the field associated with the electromagnetic wave passing through it.

RADIO SPECTRA OF ATOMS AND MOLECULES

This mention of spin interaction leads us to another exciting field of research which is very active at the present time, and which is yielding results of great interest and potentiality. I refer to the radio-frequency radiations emitted or absorbed due to transitions between two close-lying energy states which may result, for example, from the spin interactions of atomic and molecular systems. A simple case is that of the caesium atom which possesses two near-energy states corresponding to parallel and anti-parallel orientations respectively of the spins associated with the nucleus and the valence electron. According to the usual Planck relation, $E=h\upsilon$, this energy difference, E, corresponds to the characteristic frequency, $\upsilon=9192{\cdot}6$ Mc/s, and may be caused to be emitted or absorbed from atoms in the appropriate states. This principle underlies the so-called atomic clock, which is a piece of apparatus designed to achieve stabilisation of the frequency of an oscillator by reference to this characteristic frequency of the caesium atom. Just as the standardisation of the metre is based upon a fundamental property of an atomic system (the wavelength of a line selected from the spectra of either cadmium or mercury), so a radio-frequency line in the spectrum of caesium can now be used to establish a standard of frequency. This approach to the definition of the unit of time is in marked contrast to the conventional definition of the second based upon the diurnal rotation of the earth.

A further application of a molecular transition resulting in radio-frequency emission is found in the "Maser" principle, that is, *m*icrowave *a*mplification by *s*timulated *e*mission of *r*adiation. In the first embodiment of the Maser† a beam of ammonia molecules is passed into a microwave cavity which is tuned to a frequency, *f*, of the inversion spectrum of ammonia. The ammonia molecules have been thermally excited so that the population of molecules in the upper state of a radiative transition of frequency, *f*, is increased relative to the population occupying the lower state. If a microwave signal of frequency, *f*, is simultaneously fed into the cavity, then it is found that transitions of the excited molecules to the lower state are stimulated by the presence of the electromagnetic field, with the result that the output from the cavity is an amplified signal.

Amplification of other microwave frequencies can be similarly obtained if they can be associated with any suitably separated pair of energy levels, transitions between which can be stimulated by an electromagnetic field. Such close spacing of energy levels commonly result from the spin interaction effects discussed earlier, and so it appears likely that solid state Masers may soon appear utilising suitable paramagnetic elements.‡

One important point to notice about this method of microwave amplification and generation is that it need not be limited by the noise effects inseparable from the electron beams used in conventional valves, magnetrons, kystrons, and travelling-wave tubes. The electron beams used in these devices are thermally generated and possess a noise content by reason of the statistical distribution of velocities. This thermal noise sets a lower limit to the signal which can be detected, and in the Hartley relation, quoted earlier, a reduction of N is just as effective as an increase in the power of the transmitter in improving the rate of information transfer. The Maser principle may be applied to atomic systems near the absolute zero of temperature, and thus thermal noise effects may be reduced to a minimum; this suggests that amplification may be obtained at signal powers much lower than can be dealt with today. Indeed, application of these principles may well result in spectacular improvements in radio-receiving technique at microwave frequencies, particularly when applied to the detection of radiations that come from outer space.

TRANSISTORS

It would be inappropriate to close this article on the part played by scientific research in shaping the Radio Industry of today without some reference to the physics of silicon and germanium and to the transistor device which has resulted from this work. It is an odd fact that when the development of the magnetron allowed the generation of significant powers at microwave frequencies, the way to the design of radars with improved performance and resolution was opened wide—provided that a suitable receiver-detector could be devised! Fortunately, this detector was immediately to hand in the

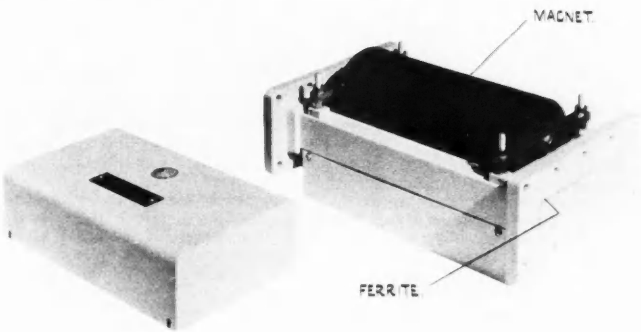

FIG. 5. Ferrite resonance uniline for 2000 Mc/s.

"cat's whisker"-silicon combination so popular in the early days of broadcasting. The success of this "crystal diode mixer" led to intensive study of the physics of the semi-conducting elements silicon and germanium, and this work has resulted in a great extension of our knowledge of the physics of the solid state; it has produced, as well, the new intriguing circuit element, the Transistor (1948), which promises to outmode the familiar thermionic valve in many circuit applications.

Although substantial progress has been made in the development of the transistor in the nine years that have elapsed since the announcement of the point contact device by the Bell Laboratories, it has to be admitted that the introduction of the transistor, even in its more stable junction form, into radio service has been slower than anticipated. Undoubtedly, the underlying reason for this slow utilisation of the device is the complexity of the phenomena involved in the behaviour of the semi-conducting material, the rectifying junction, and the associated "surface" effects. It has proved to be necessary to understand the physics of these various effects in order to correct the faults in device development and to allow precise control to be set up in the intricate production processes such as the diffusion of arsenic into silicon. It has to be recognised, however, that the difficulties to be overcome in the introduction of solid state devices have been formidable—for example, the crystal diode of the war years was required to handle a few milliampères only—but the needs of modern traction and electroplating installations can only be met by rectifiers capable of carrying currents of hundreds of ampères. To obtain the potential improvement in rectification efficiency that application of solid state rectifiers is capable of giving, it has been necessary to develop special techniques for the production of large single crystals of germanium. Fig. 6 shows a rectifier designed for a current of 250 ampères which utilises in its rectifying element a wafer of germanium cut from a single crystal of 8 sq. cm. cross-section.

The original cat's whisker-silicon detector was an empirical device that served its purpose well; the modern

FIG. 6. Germanium power rectifier, with current capacity of 250 amps.

transistor is the result of detailed physical and metallurgical studies on such subjects as purity of materials, crystal imperfections, *p* and *n* states resulting from the introduction of accurately controlled amounts of selected impurities. The transistor offers the hope of improvement in performance, price, weight, and power consumption in a whole range of radio devices, and impressive effort is now being devoted to the realisation of these hopes. But all this work depends upon the elucidation by the scientists of the complex physical phenomena involved in the device itself. This is equally true of the Maser device and of the applications of ferrites, whether to microwave components or to computer storage systems.

Can there be any doubt that the progress of the Radio Industry, and the contribution that radio can make to the modern world, are alike completely dependent upon scientific research, vigorously prosecuted and rapidly applied?

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TWENTY-FIVE YEARS AGO

ATOMS AND TELEVISION

We look back wryly (when we think of atom and hydrogen bombs), and yet proudly too (with Calder Hall and other advances to offset the bitterness), to our opening remarks in "Notes of the Month" for June 1932:

"Some excitement has been caused in the newspapers by the announcement that scientists working in the Cavendish Laboratory at Cambridge had succeeded in 'splitting the atom'. Some of the reports have been rather misleading. The popular idea that the splitting of the atom will have terrifying consequences is, of course [*sic*], quite mistaken. But the new experiments mark an important advance in a new subject with remarkable possibilities. . . . Formerly an alpha particle ejected a proton; Dr Cockcroft and Dr Walton have shown that the reverse can occur, with 'unlocking' of energy. The recent discovery of the neutron considerably widened the scope of this subject and thus paved the way to the new experiments; work on the neutron forced these workers to look out for something new instead of concentrating solely on the ejected proton. An interesting feature of the work is the fact that the results might have been obtained, with the necessary technique, at any time during the past ten years. No one thought of doing so."

The recently announced changes in programme policy on the BBC are supposed to be necessitated by the growing popularity of television, and it is therefore interesting to look back to 1932, when our "Notes" announced:

"Television broadcasts are in future to be provided by the BBC on four evenings each week. Meanwhile, the successful demonstration last month of ultra-short wave television marks an important step forward. A new type of receiver was used in which the image is thrown on a screen instead of being shown in a lens. The size of the image is considerably larger so that more spectators are enabled to take part. Mr Baird is continuing experiments both with cathode-ray and mechanical methods of reproduction."

STRINGS, ART, AND MATHEMATICS

H. R. CALVERT, M.A., D.Phil.

Science Museum, London

It is significant that when the museums and teaching establishments at South Kensington were started a hundred years ago they were administered together as the Science and Art Department, but gradually separate entities, one for science and one for art, became established, until now the divorce is complete. Everywhere there is a growing concern about the way in which science is becoming isolated from the arts and humanities.

The artist and the poet perceive things to which others are blind; and it is remarkable, as Eric Newton has pointed out in a recent broadcast talk,* that 20th-century movements in art, such as cubism and vorticism, have a mathematical and scientific theme. He points out that Ben Nicholson is entirely absorbed by a kind of visual mathematics and that Mondrian in his last phase was pushing mathematical puritanism to its extreme. Both Mondrian and Picasso rejected humanism; Mondrian willingly, because mathematics seemed to him the artist's ultimate goal; while Picasso, although as a genuine Romantic he could not reject the human figure altogether, reduced it, in his cubist period of 1910, to "a series of crystalline planes. Mondrian throws humanity overboard; Picasso turns humanity into an unusually complicated crystal."

Artists seem, as it were, to be including science and mathematics in their ambit as if, with their clairvoyant wisdom, they were aware of the danger of a total divorce of science from the arts.

The accompanying photographs illustrate this tendency. Two photographs (Figs. 1 and 4) of a composition in wood and string by Henry Moore are shown beside two photographs of mathematical models made in the eighteen-seventies. Fig. 3 shows a model of the cubic surface $xyz=k^3(x+y+z-1)^3$; and Fig. 2 is a portion of a model devised to show how hyperboloids can be generated by the motion of a straight line. Henry Moore has stated that the mathematical string models in the Science Museum provided the inspiration for some of his creations: looking at these, he saw the possibility of creating "sculpture you can see through". He also noticed that in the scientific string models the supports which held the strings were not used, and he saw a way of incorporating these into a sculptural whole.

From the other side of the fence some mathematicians are attempting to find a relationship between mathematical form and aesthetic beauty. J. Harvey has written down algebraic formulae in three variables and then constructed wooden models of the surfaces thus formulated. Modifications of the shapes can be made as desired by appropriate alterations in the formulae until an aesthetically satisfying shape of known equation has been produced; for example, a pair of ram's horns now exhibited in the Science Museum.

Symmetry is a subject which is amenable to mathematical treatment, and the theoretical physicist Hermann Weyl, in his book on the subject,† considered the aesthetic implications as well as the mathematical ones, not forgetting that the artist, as opposed to the architect, is more interested in departures from symmetry than in the strict observance of it.

The mathematical basis of the forms resulting from natural organic growth, such as sea-shells, which have inspired artists, has received some attention, notably in D'Arcy Thompson's book,‡ "On Growth and Form", and more recently in an article§ in DISCOVERY by K. J. Dormer, in February 1955.

Just as the study of the history of science seems a promising way of getting the scientist and humanist on to common ground, the mathematics of beauty provides a field in which artists and scientists can work together.

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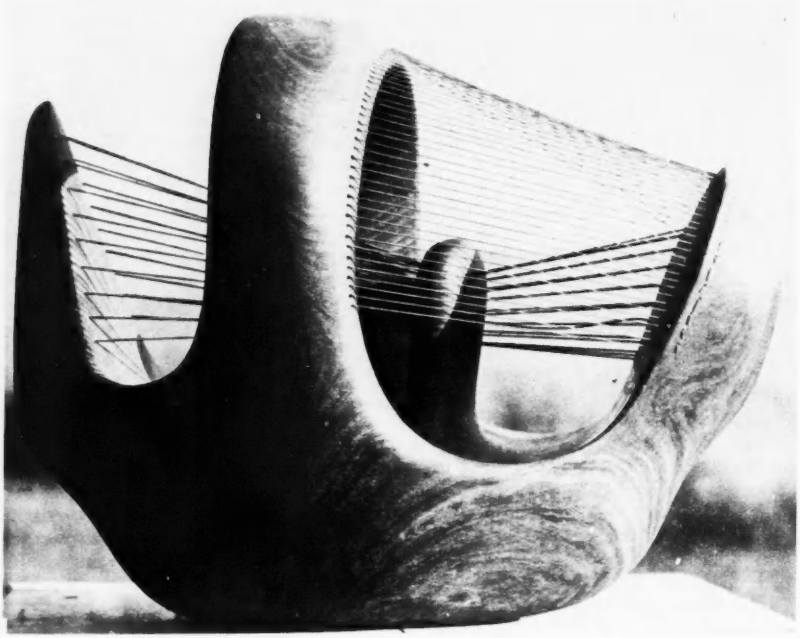

FIG. 1. "Bird Basket" in lignum vitae and string by Henry Moore, 1939. (Collection Mrs. Irina Moore.)

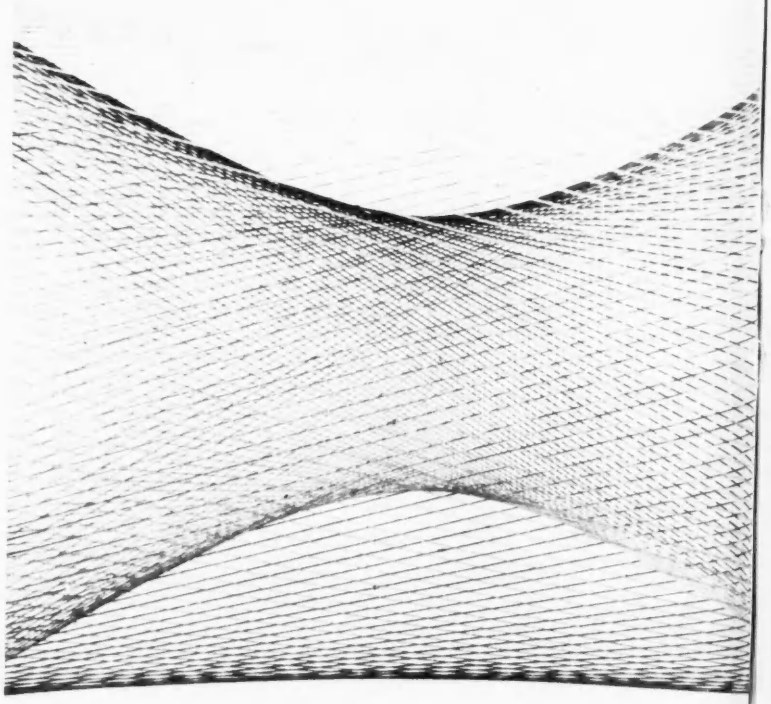

FIG. 2. A string model showing how a portion of two hyperboloids may be generated by the motion of a straight line. (*This photograph and Fig. 3 opposite are reproduced by kind permission of the Director of the Science Museum, London.*)

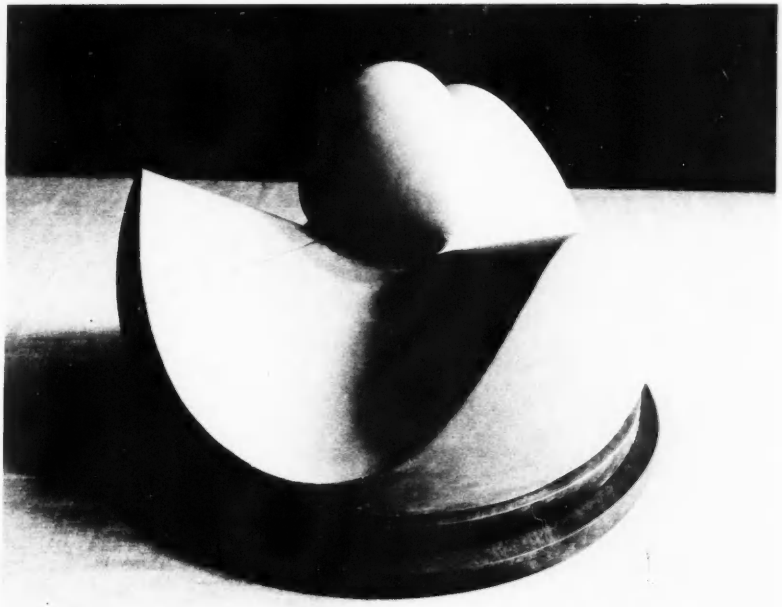

FIG. 3. A model of the cubic surface $xyz=k^3(x+y+z-1)^3$.

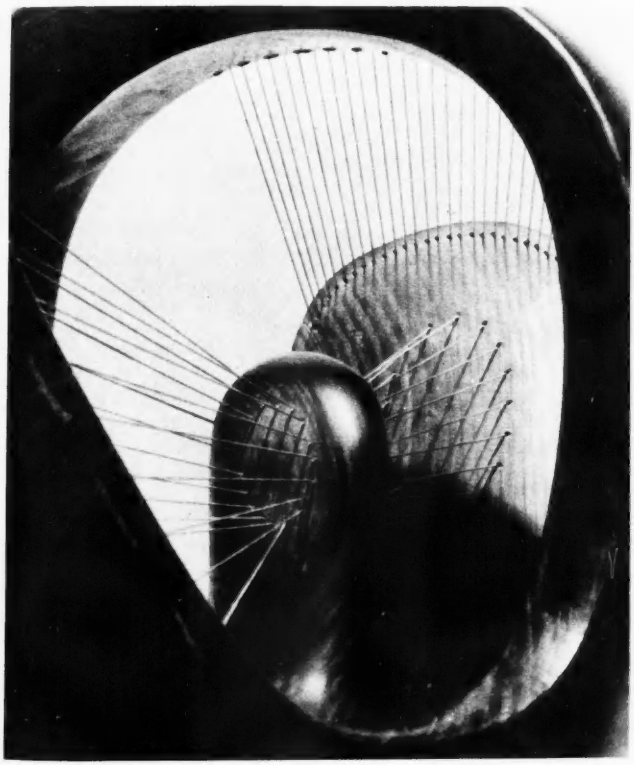

FIG. 4. The "Bird Basket" by Henry Moore, another view.

THE ORIGINS OF GARDEN ROSES

N. P. HARVEY, M.A.

In Britain, Europe, and America, the rose has long been the most widely grown of cultivated flowers. This may be illustrated by the similar spelling of the name in different countries; for instance, in English, French, German, and Danish it is *rose*, in Italian, Latin, Portuguese, Russian, and Spanish it is *rosa*. The origin of the name is uncertain but R. E. Shepherd suggests in his book, "History of the Rose", that it was originally given to the genus because the first recorded roses were deep pink.

The genus *Rosa* is distributed throughout the Northern Hemisphere. There seem to be no roses native to the Southern Hemisphere, and the half-dozen or so species which constitute the foundations of the main rose groups are all of Asiatic origin. The genus is extremely variable, and botanists often differ considerably in their estimation of the total number of species. "A Handbook of British Flowering Plants" (Edited by A. Melderis and E. B. Bangerter, 1955) places the number between 230 and 250 but about 120 is a more generally accepted figure.

Rose species are shrubs, usually with prickles which vary in size, shape, and number. For example, *R. omiensis* var. *pteracantha* has large wing-like red prickles which are translucent when young and exceptionally sharp. The plant cannot be touched without gloves. Severe pruning after flowering is necessary for the production of these large prickles. *R. stellata* has prickles and leaves similar to the gooseberry's. By contrast, *R. banksiae*, *moyesii* and *pendulina* are practically devoid of prickles. Nearly all species are deciduous.

Heights vary from a few inches in the case of *R. chinensis minima*, to the rampant-growing *R. moschata* or Musk Rose, which can attain forty feet in a warm, humid climate. Usually there are five sepals and petals but *R. omiensis* and *sericea* have only four. The fruits or hips of *Rosa* are characteristic, being usually ovoid or globose. The predominant colour is some shade of red or purplish-red, occasionally, as in *R. spinosissima*, black. The fruits of many species have considerable decorative appeal. Probably the best-known is *R. moyesii*, which bears large orange-red, flask-shaped hips. Other notable fruiting species include *R. macrophylla*, *sweginzowii* and *webbiana*.

Most rose varieties grown nowadays have probably been derived from about six species. Not less than eight further species have been employed, though sometimes with only isolated successes. With the original six,

FIG. 1. *Rosa foetida bicolor* (Austrian Copper).

FIG. 2. *Tivoli floribunda* with individual blooms like a very small Hybrid Tea (Poulsen, 1955).

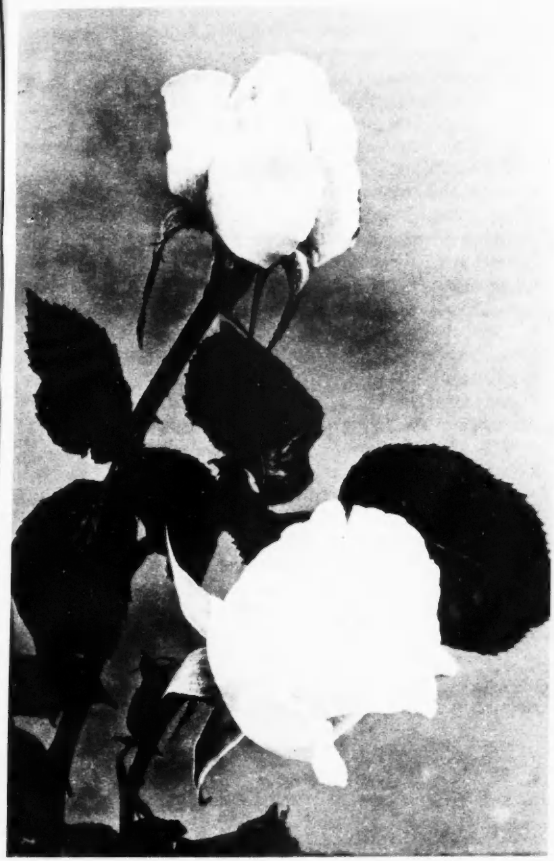

FIG. 3. Golden Revelry. Hybrid Tea (McGredy, 1952).

FIG. 4. Coy Colleen. Hybrid Tea (McGredy, 1953).

including *R. damascena, gallica,* and *wichuraiana,* development has proceeded through hybridisation, leading to the formation of new horticultural, as distinct from botanical, groups, for example, Hybrid Perpetuals, Hybrid Teas, and, more recently, Floribundas.

In her Masters Memorial Lecture, 1954, "The History of Garden Roses", Miss Ann P. Wylie discusses the part played by these species in developing garden roses, new and old, and the following summary is based largely on this excellent account. R. E. Shepherd's "History of the Rose", has also proved helpful.

WELL-KNOWN ROSE SPECIES

R. gallica is the oldest of all recorded roses and may well be the basic species from which all garden roses have been developed. Pliny the Elder (A.D. 23–79) in his "Natural History" refers to the Rose of Miletus as bearing vivid red flowers with not more than twelve petals and this was probably *R. gallica*, sometimes known as the French Rose or Rose of Provins. Shepherd states that the Dutch started raising gallica seedlings as far back as 1670, and it seems fairly certain that they were followed by the French. Much of this work was undoubtedly haphazard, involving considerable wastage, as genetics was an unknown science and accurate breeding records were very seldom kept. Few breeders had clear-cut, long-term objectives and the Tea variety Safrano (Beauregard, 1839) is claimed to be the first successful rose to be raised by artificial cross-fertilisation.

The Damask Roses may well have been derived from *R. gallica*. *R. damascena* possibly came from Syria in the immediate neighbourhood of Damascus; but whether it was brought to Europe by the Crusaders it is impossible to say. There appears to be no written record of its cultivation in England before 1520, though this does not preclude a considerably earlier introduction. There are two main groups, the summer-flowering varieties and the Autumn Damasks, which were greatly valued by the Romans.

The centifolias are a later development. *R. centifolia*, The Provence or Old Cabbage Rose, is apparently a complex hybrid, and it seems doubtful whether early writers like Pliny the Elder were really referring to this species. It is, however, possible that a few kinds were

grown in England long before this group became popular in the eighteenth century. The centifolias were completely double and at first new varieties only arose as bud sports. Hybridisation with other groups was only possible with the appearance of a single-flowered sport in the early nineteenth century. The Moss Rose *R. centifolia muscosa* is a bud sport from *R. centifolia* and was probably first noted about 1720. Over thirty Moss Roses are still available today.

The albas constitute the last group of summer-flowering roses. They may have developed as the result of chance crosses between *R. canina* and *R. gallica*, and are very distinct, both botanically and horticulturally. Whereas the gallicas, centifolias and Damasks are mostly tetraploids with 28 chromosomes, the albas are hexaploids with 42 chromosomes. They have been little used by breeders, but a few varieties remain, notably the exquisite Maiden's Blush; the grey-green foliage is very characteristic, similarly the fragrance.

Today we take for granted reasonable continuity of bloom from June to October when considering the groups of bush roses known as Hybrid Teas and Floribundas. This character is due to the introduction, between 1792 and 1824, of four cultivated Chinese roses, derivatives of *R. chinensis* and *R. gigantea*. One, Parson's Pink China, is possibly the variety known for several generations as Old Blush or Common Monthly. In a sheltered corner this variety will bloom without a break from late April to November.

Hybridising with other groups, including the Damasks, gallicas, and *R. moschata*, led to the development of the Noisettes and Bourbons, the continuous-flowering character now becoming typical of nearly all new varieties. The Noisettes (*R. moschata* × Parson's Pink China) are often happiest grown on warm south walls, although the white Mme Alfred Carrière, introduced in 1879 and still catalogued in 1957 by most rose growers, is less particular.

The Bourbons arose from a chance cross between Parson's Pink China and an old Damask variety about 1815. This occurred in Réunion (The Isle of Bourbon). The pink and purple Mme Isaac Pereire, which some consider the most fragrant of all roses, and the thornless, cerise-pink Zephirine Drouhin, still very popular as a climber for house walls, belong here.

The Tea Roses were widely favoured in the latter half of the nineteenth century. Bourbons, Noisettes, and Chinas formed the foundations of this group. Teas have been called "the aristocrats of the rose world", by reason of their finely formed blooms. We undoubtedly owe the form of present-day Hybrid Teas to this race. The subdued colourings are pleasing, but Teas demand light pruning, really fertile soil, and a warm, dry climate. Many varieties were not reliably hardy.

The Hybrid Perpetuals originated from crosses between the Hybrid Chinas, Bourbons, Portland Roses (*R. chinensis* × *R. damascena*) and possibly the Noisettes. The term "perpetual" was a misnomer, as in most varieties few blooms were produced after the first crop. This group was vigorous and hardy and very popular with rose exhibitors. The Hybrid Perpetuals crossed with the Teas produced the Hybrid Teas, which began with the silvery-pink La France (1867). They combined the continuous-flowering habit of the Teas and the hardiness of the Hybrid Perpetuals. The Hybrid Teas were available in various shades of red, pink, and white. No really deep yellow appeared until *R. foetida* was used towards the end of the nineteenth century by the French breeder J. Pernet-Ducher, whose aim was the production of a pure yellow, hardy garden rose. The first really hardy yellow was eventually raised by Alex Dickson (N. Ireland), who introduced Mrs Wemyss Quin in 1914. The orange, apricot, yellow, copper, and allied shades in present-day Hybrid Teas are derived from *R. foetida* and its variants.

Subsequent progress in the Hybrid Teas is largely accounted for by inter-crossing existing varieties. Two important developments must be noted. The variety Peace, raised by F. Meilland, of Cap d'Antibes, is stated to have the following parentage (Joanna Hill × [Charles P. Kilham × *R. foetida bicolor* seedling] × [Charles P. Kilham × Margaret McGredy]). Peace is distinguished by immense vigour compared with other Hybrid Teas and is being widely used by breeders in Europe and the British Isles. Grey Pearl (McGredy, 1945) was described by the famous American hybridist, E. S. Boerner, as the "major colour break of our time". The general colour effect is lavender-grey with shades of tan or deep pink, depending on weather conditions. This variety is erratic, sometimes extremely beautiful, at others a dull, dirty colour. Lilac Time (McGredy, 1956) appears a more reliable garden plant and the colour is attractive in all weathers.

The Dwarf Polyanthas or Polyantha Pompons originated from a cross between *R. chinensis* and *R. multiflora*. They flower in compact clusters with much smaller individual blooms than the Hybrid Teas. The plants are shorter in growth and many varieties are bud sports. The Hybrid Polyanthas began about 1920 in Denmark, where D. T. Poulsen crossed the diploid Polyantha Pompons with the tetraploid Hybrid Teas. Poulsen's objective was a race of roses capable of surviving the very low winter temperatures of northern Europe, and this new group embraced varieties growing to the same height as the average Hybrid Tea with single, semi-double, or fully double blooms in large clusters. Breeders continue to develop varieties embracing new shades of colour. Examples are: the orange-scarlet Korona (Kordes, 1954), the salmon-pink Fashion (Boerner, 1947), the multi-coloured Masquerade (Boerner, 1949), and the deep-mauve Magenta (Kordes, 1956).

The Hybrid Musks and Hybrid Sweet Briars have been used in breeding new Hybrid Polyanthas, and it has now been decided to classify all types of cluster roses as Floribundas. This horticultural definition excludes the Polyantha Pompons, Climbers, and Ramblers, also species and the taller-growing Shrub roses.

CLIMBERS AND RAMBLERS

Climbers and Ramblers (these terms are, of course, purely horticultural) can be divided nowadays into three main groups, although the complex parentage of many

varieties renders precise classification difficult. The first group comprises the large-flowered Climbers like Coral Dawn (Boerner, 1955) and Mermaid (Paul, 1917), also the Wichuraiana Climbers such as Chaplin's Pink Climber (Chaplin, 1928) and Paul's Scarlet Climber (Paul, 1916). A second group includes the Wichuraiana Ramblers like Dorothy Perkins (Jackson and Perkins, 1901) and Sanders' White (Sanders, 1912). This section produces new basal growths freely each year, whereas other types of Rambler and Climbers produce fewer basal shoots. *R. multiflora* and, subsequently, *R. wichuraiana* were employed to develop the earliest Ramblers. The third group contains the climbing sports from bush Hybrid Teas and Floribundas. The majority of flowers come on laterals and sub-laterals, necessitating horizontal training.

Space does not allow discussion of the various minor developments to some extent removed from the main streams of rose-breeding, but the various shrub-type roses raised by Kordes must be mentioned. They include Hybrid Musks such as the orange-scarlet Bonn and the apricot-orange Grandmaster.

THE FUTURE OF ROSES

What of the future? The 95% of species so far ignored by hybridists offer endless possibilities. Even within existing horticultural groups there is much work to be done. Roses with better lasting qualities are surely desirable.

Disease resistance is a very complex problem. For example, the presence of different strains of the same fungus explains the inconsistency of reports on resistance and susceptibility from one grower to another. *R. bracteata*, which has smooth, shiny foliage, is possibly the most resistant rose to Black Spot and is now being crossed with other species and varieties in the U.S.A. to determine the mode of inheritance of disease resistance.

A great deal has, of course, been achieved by nurserymen and amateurs with little or no scientific background. Nevertheless, much wastage of effort has occurred. Had breeders possessed some knowledge of genetics, more rapid progress would have been possible. It is gratifying to report that already there are indications of closer working between scientists and hybridists, both in this country and overseas.

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NEOPILINA: SURVIVAL FROM THE PALAEOZOIC

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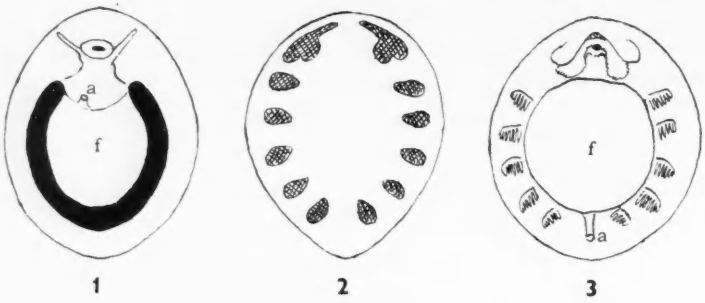
University of Glasgow

The recent preliminary description by Dr H. Lemche, from the University Zoological Museum at Copenhagen, of a new mollusc is a notable zoological event. It illuminates at once the darkness which has hitherto obscured the origin and relationships of the Mollusca. The specimens were taken at a depth of some two miles off the west of Mexico in the course of the *Galathea* Deep-sea Expedition on May 6, 1952. They look not unlike one of the many previously known kinds of limpets and were possibly so regarded until the collections were thoroughly examined. Then certainly they were perceived to be so different from any other existing mollusc as to form the first living example of a group hitherto considered as extinct since the early palaeozoic, some 400 or 500 million years ago.

The modern molluscs have hitherto been divided into five great groups or classes. The gastropods or snails have typically a coiled shell with the body twisted in a process known as torsion, so that the anus and other openings are in front. The coat of mail shells or chitons are elongate with a series of eight articulating shell plates so that they can crawl on an uneven surface like a wood-louse. The bivalves are laterally compressed with the body completely encased in a shell consisting of two valves and a connecting ligament. The tubular tusk shells form a small burrowing group. Finally come the cephalopods, consisting of the elaborately organised squids, cuttlefish, and octopods. Despite great external differences, all are built up in essentially the same way and with no trace of the segmentation found in certain of the worms and in the jointed-limbed crustaceans, insects, spiders, and centipedes.

Fossil shells could all be attributed to one or other of these five molluscan classes until relatively recently when certain limpet-like shells from the early palaeozoic were carefully studied. Previously they had been grouped with modern limpets such as the common *Patella* of our shores, in which, as shown in Fig. 1, the broad foot (*f*) is attached by a horseshoe-shaped muscle to the shell above. Only in front, where the head lies, is the muscle ring broken. These modern limpets are true gastropods, with the anus (*a*), as a result of torsion, situated in front of the foot.

But certain of these fossil limpets were found to have a series of muscle attachments, as shown in Fig. 2. This indicated that these shells were unrelated to modern limpets and indeed had probably not suffered torsion and so were not even gastropods. They might well be



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Under surface of Fig. 1, common limpet, *Patella*, showing horseshoe-shaped muscle attaching basal foot (*f*) to shell above, also head and anus (*a*) which lies in front of foot; Fig. 2, shell of early palaeozoic Monoplacophora showing six pairs of muscle scars on inner surface of shell; Fig. 3, *Neopilina galatheae* showing anus (*a*) *behind* foot (*f*), with extensive lips bordering mouth and five pairs of gill-like outgrowths between foot and edge of shell.

shells of a primitive group from which all existing molluscs had evolved. So in 1940 the Swedish malacologist, N. H. Odhner, instituted the new molluscan class Monoplacophora to include a number of these extinct molluscs with six pairs of muscle scars symmetrically arranged on the inside of the limpet-like shell (Fig. 2).

Now, only seventeen years after this class was erected a living representative is found. This new mollusc, named *Neopilina galatheae* by Dr Lemche, is not a gastropod and so is unrelated to the modern *Patella* or to any other of the numerous limpets now existing. Torsion has not occurred, the anus being at the hind end, as shown in Fig. 3. Not only are the muscles arranged in series down each side, as the scars in the shells indicated that they had been in the fossils, but many other structures have the same serial arrangement, including the auricles of the heart, the excretory organs, gill-like outgrowths (shown in Fig. 3) between the foot and the edge of the shell, and possibly also the reproductive organs.

In short, this animal is segmented, like annelids such as the earthworms and the numerous intertidal bristleworms, or the innumerable jointed-limbed animals from crustaceans to centipedes. Yet it also possesses the characteristic ground plan of the molluscs with the overarching shell formed by a dome of tissue called the mantle and with a single broad creeping surface or foot on the under side. The nervous system and the gut are no less typically molluscan, the latter possessing the characteristic lingual ribbon or radula.

Hitherto all one has been able to say about the ancestry of this great group of molluscan animals has been little more than that in early development, up to the formation of the early larval stage, there is a resemblance to the segmented or annelid worms. This trochophore larva is a minute rounded object with a ring of moving hairs or cilia used for both locomotion and feeding. It is equally unlike both an adult worm and an adult mollusc, but elongates with the first appearance of segmentation in the one case and acquires an overgrowing mantle and shell in the other. It has been usual to say that probably molluscs and segmented worms had a common origin but that the two separated in very remote time and that only after they had separated did segmentation appear in the one stock. But the condition of affairs in *Neopilina* shows that early molluscs were segmented, so that separation of worms and molluscs must have come much later than we had thought.

Far, therefore, from the molluscs being an isolated group with no very certain relationship to any other of the great invertebrate phyla, they have now acquired known ancestry and become related, distantly but very certainly, to the segmented worms and through them to the arthropod crustaceans, insects, and spiders. It is surprising that an animal should have survived over hundreds of millions of years bearing this information in the structure of its adult body, and one may reasonably speculate as to reasons why it has survived.

Probably the molluscs evolved in shallow water, where many of the exciting events in evolution must have occurred. Relatively soon after this, certain of them may have moved down the continental slope and so gradually made their way into abyssal depths, where some have persisted. Although primitive in structure and probably functionally not very efficient, they obviously proved well suited for life in a region where few animals can live because conditions are rigorous: unchanging cold, darkness, and with little food.

Judging by the presence of long lips on either side of the mouth (Fig. 3) and by the material found in the gut, *Neopilina* lives by taking in the bottom ooze with its sparse food content consisting largely of the bodies of protozoans which fall from the water above. Dr Lemche suggests that the animal lies with the shell undermost, but this seems improbable; it would surely need to move about, however slowly, to obtain enough food. There seems no reason why such a creature, living under constant conditions from season to season, from year to year, century to century, and era to era, should ever alter. *Neopilina galatheae* may well be very similar to its ancestors of the early palaeozoic. But since that remote time much has happened in shallow seas. These primitive Monoplacophora have there completely disappeared. In the bodies of existing molluscs no trace remains of the primitive segmentation still so surprisingly retained in this deep-sea monoplacophoran. It was an historic event when this was brought to the surface of the eastern central Pacific among the contents of a herring otter trawl by the Royal Danish Research Vessel *Galathea*.

PHYSICAL SOCIETY EXHIBITION, 1957

C. L. BOLTZ

In a short survey of the 41st Physical Society Exhibition only the most general trends can be considered and a few examples described. These trends were towards greater speed, accuracy, and sensitivity, more automatic performance, and the design of apparatus with outputs suitable for feeding into an electronic computer. This device, so much a novelty in past years, is now getting standardised as a tool, and the slowest part of the array is the programming. This slowness could mean that a computer, a most expensive piece of equipment, might remain in complete idleness for long periods.

Several of these trends together were seen in a voltmeter designed at the Royal Radar Research Establishment of the Ministry of Supply. It reads up to 10 millivolts with an accuracy of one part in a thousand, far higher than that of any commercial voltmeter. It is essentially a potentiometer in which a relay switch determines whether the voltage to be measured is bigger or smaller than the reference voltage. The design of this relay has been one of the problems involved, for contact voltage created in the relay switch can interfere with the accuracy of the reading. In the model demonstrated all the contacts of this switch were of platinum. The comparison having been made, a series of relays goes into operation to bring in or cut out sections of the potentiometer resistance. These sections are designed in powers of 2, and the coarsest comparison is made first, followed by the next, and so on down the scale. The result is therefore a series of digits on a binary scale suitable for direct feed into a digital computer. The voltmeter has no thermionic valves at all, but transistors and crystal rectifiers instead.

Other work at the same laboratories shows that there is nevertheless still fundamental research to be done on thermionic valves, in this case a gas-discharge tube or thyratron. Careful work on the fall of voltage across such a valve has shown that at certain voltages the previous theory does not apply.

Prof. O. R. Frisch, F.R.S., at the Cavendish Laboratory at Cambridge, has initiated the design of an apparatus for the measurement of the parameters of events in a bubble-chamber. These are photographed stereoscopically and the film is projected on to a fairly large screen. By a pantograph linkage the picture is moved about by the operator until the centre of the event—maybe a nuclear collision—is on a reference mark. This movement is analysed into two readings at right angles, and these are transferred by a photo-electric device to a punch-machine that registers the parameter on a punched tape. A third movement, bringing in the second stereoscopic view, registers the distance above or below the plane of the screen. The punched tape is suitable to be fed directly into a computer, which then calculates in a flash the range, angular deviation, and curvature of the cloud-chamber track observed.

Although computers are now established tools, great interest is being shown in the possibilities for computer work of the new materials first invented in Holland during the war, the ferrites. These are "black ceramics", made by baking iron oxide and other metal oxides together. Much has been learned about these materials in the past few years, so that, within limits, a magnetic material with any desired characteristic can be manufactured in any desired shape. Television receivers as they are known today would scarcely exist without ferrite magnetic materials. Of special interest are the so-called "square loop" ferrites in which the usual double-S hysteresis curve, familiar to everyone who has done magnetism and electricity at school, has become a rectangle. Such a ferrite can, with suitable electrical stimuli, switch sharply from one magnetic polarity to the other and thus be used as a "go or not go" device. Square-loop ferrites can thus act as the logical elements of a computer, as switches, or, with the correct modification, as storage or "memory". Plessey, Salfords, Mullard, Standard Telephones, and Fortiphone all showed ferrites at this year's exhibition.

There were six exhibits of high-speed photographic devices. The Armament Research and Development Establishment of the Ministry of Supply showed a multichannel Kerr-cell camera. A dozen plate-cameras are mounted on the periphery of a drum and can be easily adjusted for convergence on a distant object. The exposure time, because the shutter is a Kerr cell, can be as small as a tenth of a millionth of a second, and more than a million quarter-plate pictures can be taken every second. J. Langham Thompson Ltd exhibited the production version of Courtney-Pratt's image-dissection camera. The principle of this is to scan the camera aperture with a Nipkow disk, covering successfully all parts of a specially designed plate of small lenses in front of the photographic plate. The whole plate has thus a number of small photographs in sequence. These elements subsequently are unscrambled by a light source in front of the camera, and the Nipkow scanning then produces successive pictures on the plate. Up to 150,000 individual pictures a second can be produced. The camera can be used for photography in connexion with cavitation phenomena, ultrasonics, combustion processes (flame analysis), and electrical discharges. The same inventor's image-dissection can be applied to photomicrography at about 100,000 pictures per second with magnification up to 500. This adaptation is being developed by the National Research Development Corporation and was exhibited on its stand. Vinten showed a cine-camera capable of 275 frames a second, and Southern Instruments a drum camera for use with oscillographs.

Some exhibits served to remind us that not all computers are digital or even electronic. The Fuel Research Station of the DSIR has designed a computer that multiplies together two or three time-variable parameters and integrates them. The principle is that a voltage proportional to each parameter is fed continuously into a

multiplier unit. The product is plotted automatically. A free-lance research company, Nash and Thompson, have an electromechanical computer for multiplying two variables together. It consists of an electric generator whose magnetic field can be varied by a linear movement. The two variables to be multiplied—the speed of rotation of an engine and the resistance on its flywheel, for example, for the calculation of the brake horsepower—are fed to one generator, one coupled directly to the rotor and the other to the device for varying the magnetic field. The output voltage is directly proportional to the product of these two. So the result is registered on a voltmeter, which can be calibrated to read what is desired. This is a very small, robust computer, with no electronics to need servicing. Its accuracy is so good that it is limited at present by the accuracy of commercial voltmeters.

Probably the most spectacular single effort was that of Dr Dennis Gabor's flat television tube for colour. This is quite flat and only a few inches deep. The cathode-ray beam is generated at the top, sent to the bottom, and turned through nearly four right angles to come up to the screen. For colour television this tube would have the great advantage that the multi-hole mask used in many types of colour tube could be fixed permanently close to the fluorescent screen. A great deal of technological development has been achieved already, though there is still a lot to be done. The project is now sponsored by the National Research and Development Corporation.

New materials from time to time come to the front, and this year it is indium antimonide. The fact that this compound, purified by zone melting, is a sensitive detector of infra-red radiation was first announced by scientists at the Royal Radar Research Establishment. This year they showed a detector sensitive enough to register the light from a tungsten lamp several miles away, and Plessey showed the development of the material as an infra-red photocell. Barium titanate as an efficient piezoelectric crystal has been adapted to a number of strain-gauges and accelerometers, but a new material, a ceramic of lead titanate and lead zirconate, is now being produced. Radio Heaters showed transducers made of this material which will withstand temperatures up to 300°C and loadings of 50 watts per square centimetre.

Dr McArthur, now McArthur Microscopes Ltd, made a one-man show that attracted considerable attention to his compact little microscope, as portable as a camera and usable in aircraft and in difficult country where the usual bulky and awkward microscope could not be used at all. Dr McArthur originally designed one microscope for his own use in the Far East. Together with slides and records, it was captured by the Japanese in Borneo and afterwards recaptured intact. In recent years he has improved this apparatus so that it can be conveniently arranged for microphotography or binocular vision.

SCIENCE AND THE THIRD PROGRAMME

J. R. SIMONS, M.Sc., Ph.D.

Talks Producer, BBC, London

The aim of the BBC's Third Programme is to reflect the artistic and intellectual currents in British society; in a word, our cultural activities. Since science forms such an important part of present intellectual activities it is not unnatural that science and scientists, both as specialists and as members of society, should figure prominently in the programme output. The realisation of this often comes as a surprise to many scientists who may not have hitherto studied the Third's output very carefully.

As with its non-scientific programmes, the policy of the Third Programme is that the specialist himself should speak on his subject rather than that a commentator should speak for him. This attitude sometimes leads to certain difficulties in obtaining satisfactory science programmes, for it is not the easiest of things to broadcast so that a successful communication is made. It must be admitted from the outset that the scientist as broadcaster is beset with difficulties. He cannot, for instance, use diagrams, he must rely solely on the spoken word to convey his meaning and he must cut to the minimum "dry" exposition and technical jargon if he wants an audience of more than his fellow specialists to hear him out. His listeners, too, have their difficulties, for if they lose the thread of the argument they cannot refer back to a previous paragraph as when reading, nor can they take a cue from his facial expression as they can at a public lecture. Despite these difficulties many scientists have broadcast successfully, and there are undoubtedly many more who will accept the challenge of the present need to get their ideas over, not only to the general public but also to specialists in fields other than their own. The Third Programme offers them a way of doing this.

The level at which a science talk must be pitched, even on the Third Programme, requires considerable thought, for although a general tendency is to assume a lay audience which is not unfamiliar with the ideas of science, it should not be forgotten that science is a pantechnicon word rather than a portmanteau. It is a vast subject and can claim to deal with almost anything, and although there certainly exists an audience which, because of the books of Eddington and Jeans, or because of recent newspaper articles, may be familiar with astronomy or automation, the same audience cannot be assumed to have an equivalent background knowledge of, say, cell physiology, communication theory, oceanography, or any of the other thousand-and-one diverse subjects of science.

This may mean difficulties but not necessarily an impossibility as a glance at the titles of talks broadcast during 1956 will indicate. They range from "The Polar Aurora" by James Paton to "The Anatomy of Viruses" by F. C. Bawden. No less wide in range have been the "talks in series", some of which have been very well received as, for instance, Tinbergen's "The Courtship of Animals", Macmillan's "Automatic Control", and the recent series on "The Chemical Basis of Life" and "Ecology" to which various speakers contributed. Often series eventually become books, as did earlier series such as Ubbelohde's "Man and Energy" and Toulmin's "The Nature of Scientific Theory".

Apart from programmes which "popularise" science, serious consideration has been given to providing programmes primarily for the scientist. In such programmes the specialist would be able to speak to his peers without having to consider whether or not he was making himself intelligible to the non-specialist, but there has been no real conviction that this would be a legitimate activity for the Third Programme since by so doing it would be usurping the function of the specialist journals. On the other hand, there is a case for broadcasting programmes of discussions between scientists of topics of current interest in their fields of study. Such programmes, which would be thought of as minor symposia, would enable a far wider audience to hear the discussion than could gather at any one centre. As well as the scientific content of the discussion, there would also be the interest of personality present which would be lacking in any printed record of a normal symposium. As an experiment a monthly series of such "symposia" will be broadcast in the Third Programme, beginning in April, under the general title "Research", and it is hoped that the response to them will give a good indication of possible next steps in the broadcasting of science.

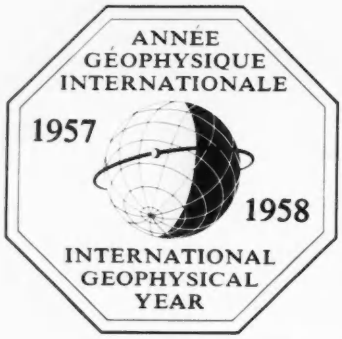
GRAVITY CHANGES IN AIRCRAFT AND SHIPS

In the *Journal of the British Interplanetary Society*, 1956, vol. 15, No. 2; March–April, Dr Harald J. A. von Beckh describes the results of experiments conducted on turtles and human beings under sub- and zero-gravity conditions. Several normal turtles were used and also one which had accidentally received a permanent injury of the labyrinth and betrayed uncoordinated movements on the ground or in the water. The injured animal behaved with complete normality under sub- and zero-gravity conditions, moving with speed and accuracy, and showing the same skill in eating as on the ground, while the others were unable to attack proffered baits. Their behaviour resembled that of the injured turtle for a few weeks *before* the experiments in the plane, and it is believed that during that time it learned to compensate for loss of labyrinthine cues by developing visual orientation, which would explain its normal functioning when that of the others was abnormal. More interesting and important are the results of the experiments with human beings under gravity-free conditions, and various tests in visual orientation and muscular co-ordination were carried out in a plane with a 1500-h.p. engine giving a diving speed of about 365 knots (616 ft. sec.$^{-1}$). Two kinds of experiments were made and in the first each subject took the test (1) in horizontal flight, (2) during radial acceleration in the direction from head to feet, and (3) during the dive under sub-gravity and zero-gravity conditions. Each test was carried out with the eyes open and also with the eyes closed, and in these the subject had to draw crosses in seven small squares arranged diagonally on a sheet of paper 21×21 centimetres which was attached to the instrument panel of the plane. Held firmly in his seat by his shoulder belts and with no available support for his hand, the following observations were made on the behaviour of the subjects:

During horizontal flight, with eyes open, the crosses were placed in the squares without difficulty. With eyes closed, the crosses were placed diagonally in the prescribed manner with only slight irregularity due to the lack of visual control. During zero-gravity, with eyes open, drawing the marks was difficult; they were made inaccurately and deviated from the established pattern, although a diagonal was usually followed. In the same conditions with eyes closed, the deviation from the diagonal direction was so pronounced that it could not be attributed solely to the lack of visual control, and the subjects experienced great difficulty in placing the crosses in the squares.

In the second type experiment during which there existed post-acceleration weightlessness, orientation was extremely affected, the disturbance occurring shortly after the beginning of the gravity-free state. The blackout lasted longer than after a normal pull-out, and vision was not restored until the aircraft entered the descending arc of the parabola. Drawing with visual control could not be started until after the fifth second of weightlessness, and the crosses then showed the same deviation from the diagonal direction that had been found under sub- and zero-gravitational conditions.

Experiments on changes of gravity in ships were carried out by placing the subjects in a dark room near the bow of the ship; they were seated on chairs screwed to the floor and their heads were fixed on head supports by means of bandages. A pin point of light was placed at a distance of between 2 to 5 metres and accelerometers were used to register gravity changes. Of seven persons, three were convinced that they had experienced the optical illusion of the displacement of the luminous point in an up and down direction. Experiments with T-33 and G-86 airplanes are now going on, and no doubt the results of these will be published in due course; they will prove valuable in connexion with the study of the behaviour of human beings in abnormal gravity conditions—an important space-flight problem.



THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome

Satellite News

Project *Vanguard* (the name by which the U.S. satellite programme is known) suffered a setback in April. After extensive static tests one of the three-stage rocket-motors that will power the launching vehicle was declared unsatisfactory. It was developed by the General Electric Company working under contract for the Office of Naval Research which has overall charge of the satellite project. General Electric have developed other rocket motors for the satellite; there has also been the suggestion that the Chrysler rocket-motor which powers the U.S. Army's *Redstone* rocket might be used.

Two spokesmen have made reassuring statements which suggest that *Vanguard* plans will not be much thrown out by the failure of this motor. John L. Hagen of Naval Research, the technical director of Project *Vanguard*, dismissed the idea that the satellite might not now be launched during the IGY. A spokesman for the Glenn L. Martin Company, which builds the satellite body itself, spoke of "some delay" but did not consider the interval would be serious.

During the same week that the first GEC *Vanguard* rocket-motor was rejected, an *Aerobee-Hi* flying from White Sands proving ground, carried prototype satellite instruments to a height of 126 miles on their first high-altitude flight-test. The chief scientist at the naval laboratory at White Sands described the performance of the equipment as "not only good but as coming up to our expectations". The point of this test (to about 100 miles high) would be to see how instruments contained in the satellite sphere and housed within the rocket nose-cone will stand up to the pressure and heating encountered as the rocket passes at speed through the lower, denser layers of the Earth's atmosphere. A full test of these instruments cannot of course be made until an actual launching takes place. A high-altitude rocket flight of this kind, however, subjects them to the severest conditions they will encounter during their 300-mile journey to the edge of space.

Earlier this spring the Air Associates Company, the government contractors charged with developing the automatic "pilot" that will supervise the progress, details, and switching, on the satellite launching flight, and which is to be housed in the second-stage of the *Vanguard* vehicle, was declared ready. The apparatus has now been handed over to the Defence Department. It has been developed by a team of ten scientists working for AAC, who describe it as a "coasting time computer".

Another computer associated with the satellite is also ready. This is the instrument that will continuously calculate and predict the satellite orbit (and therefore the position in the sky of the satellite on its "next time round"). It is designed by the IBM Corporation of New York. Head of the computing staff at the satellite computing centre in Washington is Dr Paul Herget, who is Professor of Astronomy at the University of Cincinnati. Dr Herget pinpointed the "lost" planet Athalia two years ago with the aid of a computer of similar but earlier design to that to be used for the artificial satellite. He also keeps track of 1600 minor planets for the International Astronomical Union.

It is expected that the details of the satellite's meridian passage of an outlying tracking-station will never take more than 20 minutes to reach the computing centre at Washington.

Rivalry over Lowest Temperature

The Russians have not held the record for the lowest Antarctic temperature for long. It was established with a reading of −88°F (−66·8°C) last September at the Soviet inland sub-station, Pionerskaya (DISCOVERY, January, p. 32). On April 2, 1957, the new American station at the South Pole recorded a reading of −89°F (−67·3°C). This beats the Pionerskaya record by approximately 1°F, exceeds the lowest North American reading (−81°F) by 8°F, and is within one degree of the present world record −90°F (−67·8°C) recorded in north-eastern Siberia in February 1933.

It is not likely that this South Pole record will stand for long. Lower temperatures may be expected at this same station later in the winter. Moreover, the South Pole station, though sited at 10,000 feet above sea-level, is not thought to be at the highest point the Polar Plateau reaches. Both these conditions are likely to be more nearly fulfilled by the Russian station, Sovietskaya, to be established at the so-called Pole of Relative Inaccessibility at approximately 82° S, 50° E.

The American South Pole staff made their first upper-air measurements by radio-sonde on March 27. The readings were: surface (at 10,000 feet above sea-level) −71°F; 3300 feet above the surface (13,300 above sea-level) −38°F; 11,500 feet up (21,500 above sea-level) −62°F.

One of the special interests of American meteorologists in Antarctica is the comparison of the relatively clean air of this region with the atmospheres of coal- and oil-consuming areas. This should yield data on the supposed "greenhouse" effect on the weather induced by the release of quantities of carbon dioxide.

FIDS Steps up its Scientific Research

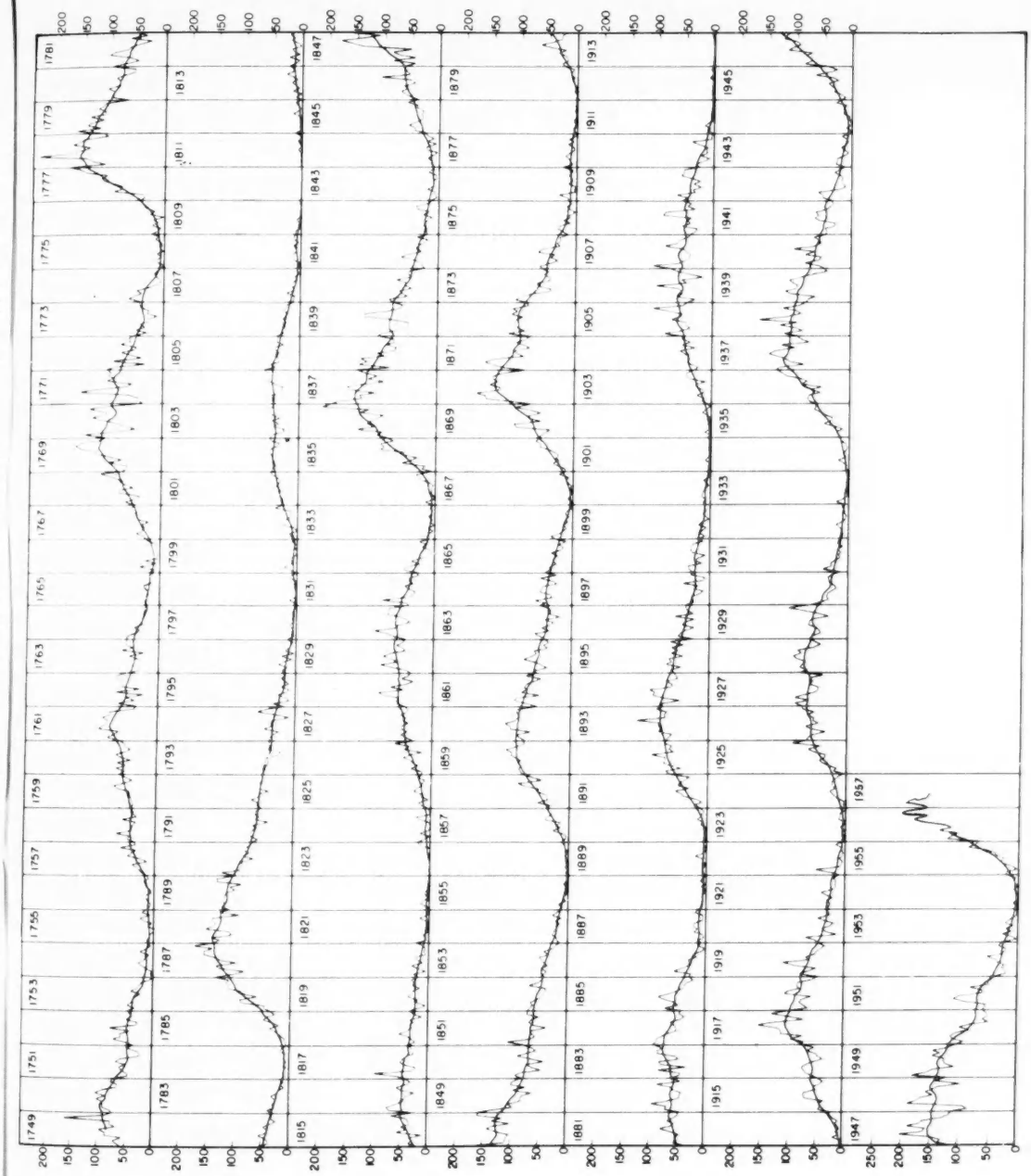
The Falkland Islands Dependencies Survey, the operating agency of Britain's eleven permanent Antarctic stations all of which have IGY programmes, is recruiting scientific and technical personnel for the coming Antarctic season. The jobs open are for radio-operators and diesel-mechanics, surveyors, geologists, and meteorologists. Young men with polar research programmes of their own that can be fitted into the overall expedition pattern are being encouraged to apply this year. Climatology, marine biology, glaciology, and zoology (including dog physiology) are some likely subjects.

This apart, FIDS now offers scholarships for geologists doing two years' Antarctic field-work which will enable them to spend enough time at an appropriate centre on their return, to work up results for publication as one of the FIDS Scientific Reports published by H.M. Stationery Office. The geologists would be attached to the recently established FIDS laboratory in the Geology department of the University of Birmingham, and the work would be eligible for presentation as a doctor's thesis in this department.

Any readers interested to apply for either type of FIDS post should forthwith get in touch with FIDS (Rear Base), 4 Millbank, London, S.W.1.

Record Sunspot Peak?

There seems little doubt that the present sunspot maximum will be one of the greatest since observations and records were first kept 208 years ago. The sunspot graph has been up near the 200 mark since last November, and radio propagation experts are predicting that the present excellent short-wave conditions over long distances, which are associated with the peak in the sunspot cycle, will continue at least until the end of 1959. The high level of geomagnetic and auroral activity, exemplified by the magnetic storm and



Observed relative sunspot numbers 1749–1956, provisionally brought up-to-date (May 1957). *(By courtesy of Page Communication Inc.)*

Final Calendar of Regular World Days (RWD) and World Meteorological Intervals (WMI) during the International Geophysical Year 1957-1958

(Adopted by CSAGI, September 1956 and edited by CSAGI SECRETARIAT - 3, AVENUE CIRCULAIRE, UCCLE-BELGIUM)

World Meteorological Interval: 20 21 22 / 23 24 25 26 27 28 29

Regular world day (11)
Regular world day at new moon (10)
Unusual meteoric activity 8 (but not world day)
Regular world day with unusual meteoric activity 17
Day of total eclipse (12)

June 1957 (Advance Trial)

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

July 1957

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14	15	16	17	18	19	20
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28	29	30	31			

August 1957

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25	26	27	28	29	30	31

September 1957

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29	30					

October 1957

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27	28	29	30	31		

November 1957

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December 1957

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8	9	10	11	12	13	14
15	16	17	18	19	20	21
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January 1958

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
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12	13	14	15	16	17	18
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February 1958

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						1
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23	24	25	26	27	28	

March 1958

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23	24	25	26	27	28	29
30	31					

April 1958

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
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20	21	22	23	24	25	26
27	28	29	30			

May 1958

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
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June 1958

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
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29	30					

July 1958

Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
		1	2	3	4	5
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December 1958

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January 1959

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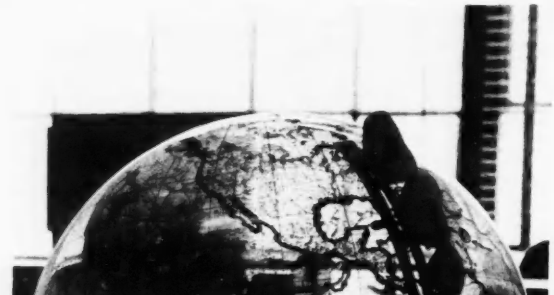


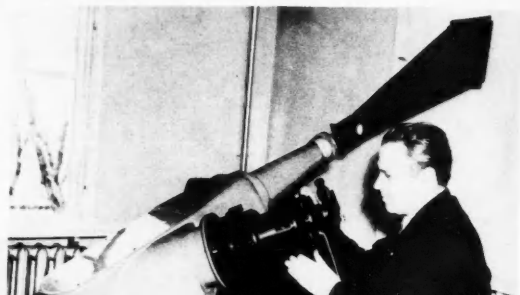


FIG. 1. A transparent globe of the world indicating the radio fence to be formed by the Minitrack radio tracking stations placed roughly along the seventy-fifth meridian and extending from a point near Washington D.C. to the tip of South America. These stations will pick up signals from the earth satellite as it passes over them in its orbit, 200 to 1500 miles above the earth.

FIG. 2. Many research institutes of the U.S.S.R. are taking part in the International Geophysical Year under the auspices of the Academy of Sciences Institute of Physics of the Atmosphere. A special observatory has been set up for study of the upper strata of the atmosphere. It is equipped with instruments to observe the luminescence of the sky at night and of the *aurora borealis*. The illustration shows Dr A. Mirnov checking the focusing of the spectrograph intended for the photographing of the sky in the infra-red section of the spectrum.

auroral display of January 21, is symptomatic.

The high-point of the current maximum phase may well top that of 1778 with a count of 240—the previous record. However, for geophysical studies a well-sustained peak is desirable; a single month's record-breaking average is of no particular interest. The peak of the cycle cannot be correctly ascertained until it is about six months past, as becomes clear from the accompanying graph of annual sunspot readings since 1749.

Station Ready at Lhasa

The IGY observatory scheduled to be set up by the Chinese in Lhasa (Tibet), as reported in DISCOVERY, July 1956, was officially inaugurated on the eve of the Chinese New Year, January 31. The main scientific programme is on the study of terrestrial magnetism and seismology; work is also being done on solar energy. It is not clear whether the investigation of the different strata of which the Tibetan Plateau is formed is considered part of the IGY or not. The plateau of Tibet (14,000 to 18,000 feet) is the highest in the world except for the plateau formed in Antarctica by the central icecap.

We are indebted for this Tibetan news to Dr Maheesh Kumar Moondhra of Calcutta.

The Antarctic Becomes Domesticated

Gardening is becoming quite the rage now in the Antarctic. It is not yet known whether Sir Edmund Hillary has installed the greenhouse he took with him, but he already has some horticultural rivals among the members of other expeditions. Last year Dr David Dalgliesh, of the Royal Society's advance party, took out some marigold seeds. These were grown in the base-hut, and have flowered with the aid of artificial light. The Norwegians recently included in their Antarctic bulletin from Dronning Maud Land the news that the hyacinths that accompanied the expedition were in flower.

Mr A. S. Helm, the New Zealand Secretary of the Ross Sea Committee, who was in the Antarctic during the past season, intends to try and grow plants *outside* during the next summer season. He returned to New Zealand this year with a 4-gallon tin filled with soil collected from near Scott Base, where it was uncontaminated by oil from the considerable oil-burning traffic that has been plying in this area this summer! The sample will be analysed for soil deficiencies, and any chemicals necessary will be flown there during the next Antarctic spring in the first U.S. *Globemaster* to leave New Zealand. Hardy plants which may prove a match for South-polar conditions will also be sent to the Antarctic.

Two of the grains of maize from a pocketful collected by an American officer from the pony fodder remaining after forty-nine years in Shackleton's Cape Royds hut, have sprouted. Some of the seed was planted in New Zealand and some in the United States. The latter produced a cob or two but was rather stunted.

It has been seriously suggested that McMurdo Sound off the Ross ice shelf would be a summer attraction for tourists, and a company should be floated in New Zealand to run a pleasure cruise there. Comdr M. B. Jackson, U.S.N., of the *Curtiss*, pointed out in Auckland recently that in summer there is no pack-ice at all in this area. A pleasure steamer could sail right round the Sound without any difficulty.

On one of the last supply trips over the South Pole station a consignment of fresh New Zealand eggs was parachuted from a transport aircraft to enliven the American party's diet. None was broken, the station reported by radio.

Soon after relieving the Shackleton station of the Trans-Antarctic party this year, coal-seams were observed (from the air) in the scarp of part of the Theron Mountains that lie some distance inland to the south. Shortly after this, a landing was made and samples of the deposit taken. On returning from this trip Dr Fuchs was clearly in great spirits at the find—"This is really good-quality coal, not like the stuff they have on the other side . . ." he is reported as saying. This refers to the coal found in the mountains of Victoria Land, edging the Ross Sea, by British expeditions before the First World War.

SCIENCE ON THE SCREEN

The Photo-Fair

Any scientist visiting this "first full-scale international photographic exhibition" would be sadly disappointed. Photography and cinematography are playing an ever-increasing role in scientific and industrial research and one would therefore expect that this trend would clearly show; unfortunately neither the British nor the Continental exhibitors at Olympia during April 11 to 17, 1957, appear to have been aware of this application of their wares. To them photography and cinematography is still predominantly represented by the amateur, using the Box Brownie type of camera if he is poor, or if he is rich an elaborate leather case full of lenses and accessories for his Leica-type 35 mm. camera. Similarly if the amateur wants to make movies, then for him there are many 8 mm. cameras.

However, there were a few scientific cameras and accessories. It was pleasant to see that De Vere (Kensington) Ltd are now again manufacturing the renowned Kamm stand which has the very wide range of heights, from 8 feet 6 inches to floor level. Every angle or position can be obtained with this stand for any photographic or cinematographic camera weighing up to 16 lb. I have used one of these stands for many different assignments in scientific cinematography and have found it very useful under all conditions. It sells for £115. Among the photographic cameras on view, the Exacta Varex IIa is probably the most useful for scientific work; it is obtainable from Clarke and Jones Ltd, George Street, W.1. Its through-the-lens viewfinder makes it ideal for either photomicrography, photomacrography, or for use with tele-objectives. A wide range of scientific accessories are now offered for sale, for example two microscope attachments, an endoscope attachment and a special electronic flash ring surrounding the lens, the Kolpofot. This flash, in combination with suitable extension rings, has produced outstanding records of shallow body cavities. A full range of lenses from 35 mm. to 500 mm. focal length are of course available and should stereoscopic photographs be required, then a special beam-splitter can be screwed into the taking lens. An interesting new lens, shown for the first time at the fair, was the Makro-Kilnar, 90 mm., f 2·8. It has a focusing range from 8 inches to infinity, covering both 35 mm. film and $2\frac{1}{4} \times 2\frac{1}{4}$ plate, with 28° and 48° angles of view respectively. It is made by H. Kilfitt, Munich, and is available from Industrial Photo Equipment Ltd, Berners Street, W.1. It should find a useful place in certain scientific, and especially medical, work where its unique focusing range is an advantage.

For the scientific cinematographer, the only new accessory was the Paillard Bolex underwater case for the H 16. Now available as a standard fitting, it appears solidly made, and is recommended as being safe to 100 m. depth, although one doubts whether the transparent plastic plate used in the iconometer-type viewfinder, will last for very long, especially on a sandy beach. It also appears strange that now, when the H 16 has a through-the-lens viewfinder, no provision has been made for using this finder underwater, although the Aquaflex used this method as long as seven years ago (DISCOVERY, 1950, vol. 11, p. 112). This through-the-lens viewfinder, of the beamsplitter type, has twenty glass-air interfaces, and in spite of their blooming, produces a somewhat dark picture. However, this finder now brings the Bolex into line with the Arriflex, the Pathé Webo, and other 35 mm. cine cameras, at a price accessible to most scientific laboratories.

A. R. MICHAELIS

Travellers Yarn

Made by Wallace Productions for Courtaulds. 16 and 35 mm. Sound. 15 mins. Available from: Sound Services Ltd, S.W.19.

Before the war almost all tyres were reinforced with cotton; now it is rayon; in the U.S.A. it is beginning to be nylon, and the French firm of Michelin have put on the market a tyre reinforced with steel wire. Tyres, no less than the springs and the steering components, are a vital element in the suspension of the modern vehicle; their properties influence the lay-out and geometry of the suspension. Tyres need to be light and strong; their life span depends largely on the rate at which heat is developed and dissipated in their walls on flexing.

In all these respects rayon has great advantages over cotton, and for that reason has supplanted it in tyres, and is rapidly supplanting it also in conveyor belting and for similar uses. How it will compare with nylon and other synthetic fibres, and with steel, remains to be seen. Courtaulds, the pioneer in high tenacity viscose rayon yarns, and their principal producer in Great Britain, have commissioned a film "Travellers Yarn" to advertise the use of rayon in tyres. A cartoon section shows the stresses to which tyres are subjected in use. Then, necessarily cursorily, we see the preparation of viscose yarn from logs of wood; the doubling and twisting of the yarn into cord; the weaving of the cord into a special cloth in which almost all the cords lie in the warp; the coating of the cloth with rubber; the cutting of the coated cloth into bias strips; the building of a tyre from these strips; and the testing of a finished tyre in a special test rig.

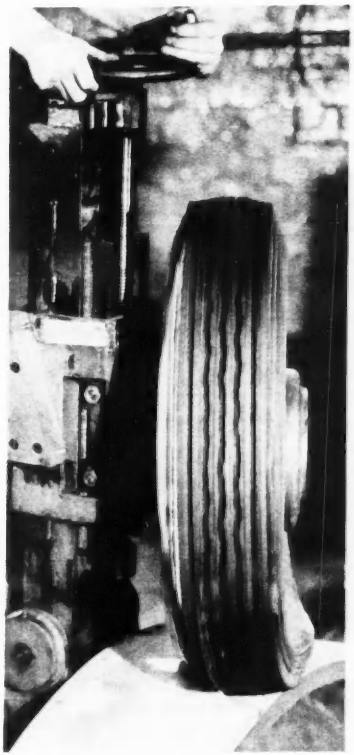
"Travellers Yarn" can be recommended as an introductory survey of the subject, presented from the point of view of an interested party—one of several competing industrial firms.

S. MASTERMAN

Television

At the time of writing, the BBC has only provided one more programme in the serial "A Question of Science", and it was in fact the last in the winter series; a new series began on April 26, too late for this review.

The programme was disappointing. The first item was about the difference



A high-tenacity rayon reinforced tyre being tested on a "cornering force" machine. From the film "Travellers Yarn".

between real and cultured pearls, and though introduced by a very cultured biologist, had little of scientific flavour in it. It resembled a second-rate documentary of the "Pictorial" or "cine-magazine" type. We were shown film sequences taken in Japan of girls diving for oysters and others in the laboratory introducing the pearl-producing tissue into the oysters, which were then returned to the sea in baskets; then an expert in a Hatton Garden laboratory showed us how cultured pearls are distinguished from natural by comparing the paths of a minute beam of light in the two cases; finally we learnt that an acid skin can wear pearls away. All interesting enough, but it can hardly have done much to increase public awareness of science.

The second item, on plastics, seemed to be preaching to the converted. Surely everyone these days knows (*a*) that there is a wide range of man-made plastics, and (*b*) that you can buy polythene washing-up bowls, nylon combs, and PVC mackintoshes.

An item on tranquilisers and stimulants, certainly topical enough, suffered from lack of visual material while a doctor just talked, and from some poorly shot film inserts of monkey behaviour under a tranquiliser, apparently dug up from the early days of the cinematograph.

The BBC's programme "Science in Britain", a survey based on the Reith lectures by Sir Edward Appleton and comperèd by him, was a rather better affair. Starting with quick historic sketches of the Royal Society and the Greenwich Royal Observatory, it took us, equally briefly, to the Cavendish Laboratory, J. J. Thomson, Rutherford, Cockcroft, and Walton, and a modern 2-million-volt generator. Next, Appleton told us about Marconi, radio waves, and Heaviside's theory, later proved correct, of a reflecting layer, the ionosphere (but rather modestly didn't refer to the Appleton layer at all). The results—we now use the best wavelength for any given job, as in radar for instance. And so to Jodrell Bank, where still shorter wavelengths are used to pierce through the ionosphere, and to radio-astronomy, meteors, aurorae, and echoes from the moon. Dr Lovell introduced us to the new radio-telescope with which it is hoped to penetrate to the farthest corners of the universe. There was a thread of continuity in all this—one topic led to another, if a little breathlessly.

Sir Edward then followed with a summary of Government and national work in applied science—defence research, medicine, agriculture, housing, road safety, and so on—and the work of organisations like NPL, DSIR, the co-operative research associations, the World Influenza Centre. Sir Christopher Hinton had a few words to say about Calder Hall, and then we were swept into a whirl of automation—rolling mills, food processing, the motor industry, teleprinters, and digital computers used in machining an unspecified part of something. All this, though well-intentioned, was too fast and confusing to do more than leave a vague general impression of what science is up to in Britain today.

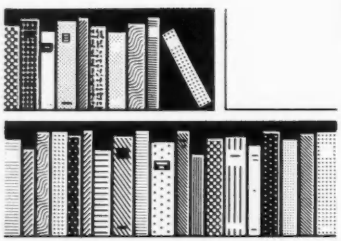
The last section, in which Sir Edward showed us what schools and universities are doing to remedy our shortage of scientists, was much more revealing. As a postscript he pointed out that modern science could easily be turned against the dignity of man—not only in war but by encompassing him with machines and material devices: "It is our own creation," he said, "let us be its master and not its servant."

After the news on Thursday, April 18, the BBC television gave us a few brief facts about the Arend-Roland comet. Three experts spoke, and one, Mr Henry Wildey, showed a home-made camera with which he hoped to obtain photographs. It would be interesting to know how many viewers will have been stimulated to look for the comet.

Since the ITV science series continues at 6 p.m., I have still been unable to see any of these programmes.

DENIS SEGALLER

THE BOOKSHELF



Science and the Nation: The Reith Lectures, 1956

By Sir Edward Appleton (*Edinburgh University Press, 1957, 140 pp., 10s. 6d.*)

Since they began in 1948 with Bertrand Russell's lectures on "Authority and the Individual", the Reith Lectures have become a feature of our national life. Our Sunday evenings are enriched by them for a few weeks before Christmas, and the subsequent publication helps us to assess their true character and message. Whilst the topics have varied widely from Prof. Oppenheimer's series on "Science and the Common Understanding", in 1953, to Nikolaus Pevsner on "The Englishness of English Art", in 1955, the quality of these lectures is always high. Some lecturers have been inspiring, whilst others have concentrated more on the straightforward presentation of facts. In the former category Sir Oliver Franks' masterly review of "Britain and the Tide of World Affairs" inspired in us the confidence that Britain could, and should, keep her place as a world power. In the latter category, on the other hand, Lord Radcliffe's lectures on "The Problem of Power" in 1951 gave a factual review of constitutional history, and particularly the use and abuse of absolute power; and now Sir Edward Appleton has given a similar review of the use of science. The title "Science and the Nation" is a little misleading in that the lectures deal not with the enormous potential value of science to the whole nation and the large part it plays in our everyday lives, but only with those parts of the nation which are directly concerned with science and its operation.

In successive lectures Sir Edward gives detailed accounts with examples of our use of science in war-time; its advancement at universities, by the Government, and in industry; and he concludes with a resumé of the present facilities for, and future developments of, education for our young scientists of tomorrow. As he states in his preface, Sir Edward has aimed his lectures at the parent and school teacher of the future scientist, to show them the rewards and disadvantages of such a career. Through the whole series the theme is a clear appeal for more technologists in all branches of science.

Unfortunately, though technology has long been considered an important career in the United States and Russia, we in Britain have not paid it sufficient attention. Sir Oliver Franks in one of his lectures summarised the situation very neatly:

> "Our traditions are different. We recognise the high place of pure science. For centuries men have found enduring satisfaction in exploring the mysteries of nature. But applied science, engineering, the process of industry—no, these are not on the same footing. Most useful, no doubt, but not inherently distinguished."

This situation is studied from a factual viewpoint by Sir Edward, who considers that it is this condescension which has limited our output of technologists and left such a gap between our pure scientists and the mass of comparatively untrained technicians. Whereas our proportion of pure scientists to population is higher than in most other countries, the relative shortage of technologists in the United Kingdom allows other countries instead of us to benefit from our inventions.

Sir Edward is quite at home when dealing with university and Government science, in particular their application in war-time, as much of his work was directed towards the war effort. He stresses, and most of us will agree with him, that the scientist cannot shrug his shoulders at the uses for which his inventions are employed. The scientist does not lose his moral responsibility by becoming a scientist: he is still a member of the public. It must be realised, however, that many inventions, though primarily discovered and exploited for the purpose of waging war, are of great use in time of peace, and one hopes that this will be the case with atomic energy.

The research scientist at a university is engaged on pure science, searching for knowledge for its own sake, and thus provides the first indication of possible new processes which may be exploited later by the applied scientist in Government or industry.

The Government, on the other hand, in its pursuit of both pure and applied science, acquires knowledge for public use, is provided with scientific advice when required, and stimulates industrial research. By centralising this research under DSIR, any possibility of administrative pressure or duplication of effort is avoided.

In discussing the scientist in industry, however, Sir Edward is perhaps least at home. He states that the needs of the technologist are not only "wide theoretical knowledge and stubborn determination, but also creative qualities of the highest order", and that he is important in the pilot plant and later stages of the process. Yet he does not follow up this idea and appears to consider that the technologist acts as the intermediate between men of thought who discover the basic principles of science and their possible applications, and men of action who run the final plant or process. This work does require an applied scientist of great imagination, but the technologist is not merely the man who develops a new process from the end of its laboratory stage through the pilot plant to the start-up of the factory; he is also the man of action responsible for constructing and operating the final plant. He suggests that the full-scale plant is controlled by unskilled labour, which will be replaced by automation in the near future, and ignores the vital part played by the technologist at this stage to ensure smooth and efficient operation. This is somewhat misleading, as it is the unskilled worker who may find himself redundant due to automation, and for whom industry must develop further training schemes.

It is with the problem of education for technicians and technologists that Sir Edward ends his lectures. The present facilities are insufficient and he stresses the need for more technological colleges to provide that wide grounding in all branches of science that our technical staff often lack. While he champions specialisation in post-graduate work, he warns against isolation and stresses the need for a thorough grounding in all subjects at school and in all aspects of science at college. Without this general background the scientist tends to look inwards instead of outwards, and to lose his sense of perspective in viewing science against life in general. This expansion of his fields of knowledge increases his adaptability. To produce such scientists the standard of teachers should, if possible, be raised, since it is by their interest more than by their factual knowledge that future generations will be inspired to pursue this absorbing subject.

JOHN A. ORIEL

Nuclear Explosions and Their Effects

(Publications Division, Government of India, 1957, 180 pp., 7s. 6d.)

The Indian Government's official statements that it will never build or use atomic weapons, and its condemnation of the testing of such weapons (especially "Hydrogen" bombs), is well known. It is therefore to be expected that a book of this type, written for that Government's Ministry of Information, will pursue such a line. Since the book has been prepared in the main by Dr Kothari with help from Dr Homi Bhabha, both men of the highest scientific integrity, there necessarily results some clash between the political line and the scientific facts. Thus Prime Minister Nehru in his foreword, after referring to the genetic problem says: "But even without war we have what are called nuclear test explosions, which in some measure spread this evil thing over large parts of the world. These explosions continue in spite of the dangers inherent in them." The argument, however, loses some of its force when, after close scrutiny, the scientific conclusion which emerges and is stated on p. 179 is: "It therefore seems that the genetic harm already done to mankind from past test explosions is probably negligible."

The biological argument which can be brought against test explosions (and then only in the case of megaton weapons deriving their energy from fission—that is, not true thermonuclear weapons) is on the score of world-wide radio-strontium contamination. This issue is considered at great length and, making what most scientists would consider to be rather pessimistic assumptions, the statement is made that "If further (megaton) tests, even on the present scale, are continued, then the possibility cannot be dismissed that at the end of a decade or so the radio-strontium body burden may exceed the permissible burden by an appreciable factor, causing a noticeable rise in skeletal injuries and other untoward effects."

This conclusion should be read in the light of the British Medical Council report (H.M.S.O. Cmd. 9780) which states:

> "Account must be taken, however, of the *internal* radiation from the radioactive strontium which is beginning to accumulate in bone. At its present level, no detectable increase in the incidence of ill-effects is to be expected. Nevertheless, recognising all the inadequacy of our present knowledge, we cannot ignore the possibility that, if the rate of firing increases and particularly if greater numbers of thermonuclear weapons are used, we could within the lifetime of some now living, be approaching levels at which ill-effects might be produced in a small number of the population."

Provided some allowance is made for this anti-weapon slant, there is much to recommend this book. It is inexpensive, well produced, and includes a number of very useful charts; the discussion of the genetic problem is one of the most detailed and among the best I have seen. The book deals with all effects of weapons: blast, heat, radiation, fallout and so on for all weapon types, low yield and high yield. It will interest people working on weapon programmes to read what competent scientists with no inside knowledge can deduce (correctly or incorrectly) about weapon techniques from measurements of fallout and the odd bits of information which can be garnered and pieced together from official releases. The book is, perhaps, a little too technical for the general public, but readers of DISCOVERY will find that the arguments can be followed without difficulty.

E. W. TITTERTON

Rock Paintings of the Drakensberg

By A. R. Willcox *(London, Max Parrish, 1956, 97 pp., 80s.)*

South Africa is, from the ecological point of view, a blind alley and if there flourished there, maybe in late Tertiary times, ape-men or men-apes of a type very possibly resembling that of some of the direct ancestors of *homo sapiens*, there is no doubt that, for ages from the late Pleistocene, the main, if not the only sort of man in southern Africa was the Bushman, or at least, the Bushmanoid. The Bushmen are now confined to the Kalahari Desert and to some regions of South-West Africa although there were a few in the Cape Province until the sixties of the last century; the last Natal Bushman is said to have died as recently as 1890.

The Bushmen were accomplished pictorial artists although we cannot state definitely that all the engravings and rock-paintings of southern Africa in general were executed by the ingenious little yellow men who lived happily enough in their Stone Age culture until they were hounded to extinction by the Bantu-speaking "Kaffirs" and by immigrant Europeans.

Africa contains, from north to south,

a far greater number of "prehistoric" rupestral paintings and engravings than does Europe, but although, for many reasons, the prehistoric paintings of France and Spain can be fairly well dated, we have but few pointers to guide us in an attempt to assign a dating to African rock-pictures in general. There are some radio-carbon readings for a few of the southern African sites (for example, Solwezi, Phillipp's Cave, and Bambata) but these readings are unreliable as far as the pictures are concerned.

Undoubtedly many of the African rock-paintings show curious resemblances to some of the European. If we look at Mr Willcox's excellent colour-photographs we cannot help being struck by the likeness a number of them show to the rock-paintings executed by the (probably) mesolithic populations of eastern Spain, who produced what is generally called the "Levantine" prehistoric art of that country. These Spanish pictures may be 8000, even 10.000 years old, but it would be daring indeed to attribute such an age to any of the "Bushman" art of southern Africa. No doubt certain kinds of art, certain sorts of representations of men and of animals reflect certain phases of cultural development, certain ways of life. The Bushmen of southern Africa were nomadic hunters as were the western Europeans of late palaeolithic and of mesolithic times.

Obviously some of the South-African rock-paintings are quite modern, for example, those with representations of Europeans, of horses and even of Bantus who do not seem to have crossed the Limpopo much before the end of the 12th century or to have reached the western part of Cape Province until about 1600, that is to say, long after Diaz had discovered the Cape of Good Hope.

Mr Willcox's monograph is confined to a consideration of the rock-paintings in the sandstone shelters of the Drakensberg range abutting upon Basutoland and eastern Cape Province, the region that has been converted into a national park and game reserve. All the stone artefacts yet found in this area are "Upper Smithfield", that is to say comparatively modern. No extinct animals are represented except those which have been killed off during the last few generations. Mr Willcox holds that the only "foreigners" depicted (save Europeans such as British soldiers) are Bantus, and he finds no reason to agree with the Abbé Breuil's theories concerning pictures of visitors from the Ancient East.

We are given an interesting account of what is known of Bushman history, manners, customs, mythology, and artistic activities. There is sensible comment on the "clear vision" of the Bushman artists and on their freedom from the bondage to the concept that so often blinds the so-called civilised.

The book is not only a model of careful description and of prudent conjecture, but it also arouses in the reader's mind a host of exciting comparisons. We can only hope that similar monographs may be forthcoming on rock-paintings in other parts of southern and eastern Africa. When we have a corpus of documentation similar to that which exists for European prehistoric art, then we may be able to see clearer into the puzzling and fascinating problems presented by the mass of African rock-paintings and engravings that are scattered about Africa from Algeria and the Fezzan, through the Sahara and East Africa, and the Rhodesias down into South Africa whose soil has, in quite recent times, revealed so much that is illuminating about our ancestry and our origins.

ALAN HOUGHTON BRODRICK

Inside the Atom

By Isaac Asimov (*London, Abelard-Schuman Ltd, 1956, 176 pp., 24 figures, 12s. 6d.*)

In his new book Isaac Asimov gives a masterful presentation of the properties and internal structure of atomic nuclei, their natural and artificial transmutations, and the methods of practical utilisation of tremendous amounts of energy which lie hidden in their interior. In simple and picturesque language he leads the reader through the history of the subject from the discovery of the atomic nucleus itself and the early studies of its properties to the present wide-flung field of the application of atomic energy. From the opening chapters the reader learns about protons and neutrons, those basic structural units of the atomic nucleus, and about the swarm of electrons which form the outer body of the atom. He learns later about the discovery of radioactive phenomena which gave us the first indication of the tremendous amounts of energy which can be liberated in the transformation of one atom into another, and the first experiments on artificial atomic transmutations. A considerable space is dedicated to the discussion of more recent advances in atomic alchemy which was opened by the construction of giant "atom smashers", and the additional information concerning the structure and properties of atomic nuclei gained by that method. This brings the discussion into the modern field of atomic fission and fusion, and the large-scale liberation of atomic energy connected with these processes. The last two chapters (out of eight) contain the discussion of atomic dangers (bombs) and atomic hopes (peaceful uses) connected with this new power given to humanity. In contrast to many other books on the subject, which rush through the basic facts concerning the structure of atoms and their nuclei to concentrate on most recent flashy developments, the book is very well balanced. The reader who goes carefully through it is guaranteed to gain a complete picture of modern nuclear physics, and will not only learn to talk about "fission" and "fusion". The illustrations which accompany the text are very well done, and will help quite a bit towards the understanding of the subject.

The book can be highly recommended to those who want to gain insight into this important branch of science.

G. GAMOW

Sea Fisheries: Their Investigation in the United Kingdom

Edited by Michael Graham (*London, Edward Arnold, 1956, xii+487 pp.+12 plates, 5 guineas net*)

This very important treatise has been long awaited by some who recall plans laid before the last war by Mr Graham's distinguished predecessor, the late Dr E. S. Russell. The figures and pictures are arranged and described as perfectly as those who know the editor's exacting nature would expect. To write that the book is immensely authoritative is not to over-praise it. A brief but forceful introduction by the editor is followed by an account of the fisheries of the United Kingdom by Dr Henry Wood, deputy director of the Aberdeen Marine Laboratory of the Scottish Home Department. This chapter contains excellent diagrams of various fishing gears and effective illustrations of their operation from shipboard. Dr Wood, an eminent expert on the herring, does not limit himself to pelagic fish and their commercial capture, but deals in detail with demersal fish as well, giving the reader a good account of the gears used in both types of fishery. His illustrations are a worthy feature of such an important book; so good are they that a reader knowing nothing of commercial fishing on the high seas can understand how catching operations are carried on.

Dr C. E. Lucas, director of fisheries research at Aberdeen, has a chapter on plankton and basic production. Interesting history is combined with an account of the habits, growth conditions, distributions, seasonal abundances, and vital importance of those minute vegetable and animal components of the sea's living matter upon which the whole food chain up to the marketable fish depends. The fact that Dr Lucas has written so fully is perhaps the reason why there is no contribution by Mr R. S. Wimpenny—Mr Graham's deputy—who has made such long, detailed, and painstaking researches on marine plankton.

The authorship of the chapter on shellfish is no surprise, for Dr Cole's experience and achievements are known to all who will turn to this book for professional reasons. All shellfish of commercial importance receive close attention, and we find a useful account of the cleansing of mussels from sewage pollution carried out at Conway so successfully as to have "stood the test

of thirty years' working", and to have "been adopted for use elsewhere with equally satisfactory results". Dodgson's work in this connexion is referred to as a solution whose brilliance resides in its essential simplicity. Regarding the research on oyster purification carried out at Conway, which later led to the building and operating of the first British oyster cleansing station at Brightlingsea, in Essex, it is pleasant to see recognition of the work of the late Mr H. M. Webb. Amongst other interesting topics dealt with by Dr Cole is crab migration.

A chapter headed "The Pelagic Phase" is by Mr A. C. Simpson, a colleague of the editor's who is known for his close studies on the plaice eggs of the southern North Sea. This chapter will interest those who have sought to relate the upgrowth fortune of fish broods to the environmental physical conditions which prevailed when they originated. Mr Simpson's chapter gives a diversity of information which would otherwise have to be gleaned from extensive reading.

"The Cod, Haddock, and Hake" are dealt with by Mr B. B. Parrish. The problem of overfishing is discussed, and the importance of these three species is stressed. There is a discussion of distribution, with some attention paid to water conditions; we are told about marking experiments, about year-class fluctuations, and about age-determination methods. Parrish naturally refers to the work of Graham, Thompson and Raitt, and Hickling.

Studies of the spawning phase, the demersal phase, growth, and recruitment, are followed by an account of how mortalities may be calculated. Parrish tells us that in the haddock "the factors determining the numerical strength of each brood are operative during the pelagic phases of the haddock's life history", and then describes attempts which have been made to establish a causative connexion between haddock fortunes and the wind conditions which prevailed at spawning time.

Mr Graham deals with plaice. He describes relevant water movements, the brilliantly simple net-throttling device of Goodchild which proved the escape of young fish from the trawl during the tow, and the financial aspects of plaice transplantation. A treatise on the theory of fishing is by two experts, Beverton and Holt, whose work has gained international repute. The vital importance of the topic is self-evident; it is the basis for right decision on how man should best apply his fishing effort to achieve that "Rational Exploitation of the Sea" which is the aim of the International Council for the Exploration of the Sea.

Finally, in few pages Mr Graham knits together the subject matter of the diverse chapters of the book into a co-ordinated whole. Despite the high degree of condensation, the chapter contrives to be lucid.

This book describes only "the fisheries from which fish are carried to the British Islands by the men who catch them". The present reviewer will not be alone in deploring the absence of a chapter on the herring by Dr W. C. Hodgson, the eminent authority on that fish. It is also a shortcoming that there is no special chapter devoted to fish/water interrelationships even though hydrographical considerations are mentioned "at points where they are particularly relevant". Because of this second omission the reader will be the more grateful to Fleming and Laevastu for their recent (1956) paper: "The Influence of Hydrographic Conditions on the Behaviour of Fish."

J. N. CARRUTHERS

Brief Notes

All publications dealing seriously with the history of science are to be welcomed, whether the history is ancient or modern. To the latter category belongs a Dover publication, distributed in England by The Mayflower Publishing Company in conjunction with Vision Press. Its subject is the "Foundations of Nuclear Physics", and it contains thirteen facsimile reproductions of those original research papers which in the opinion of the editor, Prof. Robert T. Beyer of Brown University, are the most fundamental studies in the history of the subject. Naturally the choice is a highly individual one, but papers by C. D. Anderson, J. Chadwick, J. D. Cockcroft, E. T. S. Walton, Mme I. Curie, M. F. Joliot, E. Fermi, R. Frisch, O. Stern, G. Gamow, O. Hohn, F. Strassmann, E. O. Lawrence, M. S. Livingstone, E. Rutherford, and H. Yukawa are included. A 100-page bibliography to other publications completes this 272-page book, selling at 14*s*.

With the IGY imminent, it is interesting to see two new books, dealing soberly and realistically with space travel; no doubt both authors and publishers expect the increased public interest in artificial satellites to produce a ready readership. Both are compilations of a series of scientific papers. The first, "Realities of Space Travel" (Putnam, 420 pp., 35*s*.), is edited by L. J. Carter and consists of a selection of twenty-four papers, published previously by the British Interplanetary Society. They deal with the history of the subject, the satellite vehicle, interplanetary flight, physical and biological aspects of space flight, rocket testing stations, targets for tomorrow, and interstellar flight. The contributions are of the usual high standard and provide a comprehensive selection; an interesting appendix lists twenty-four interplanetary societies all over the world, an indication of the wide interest in the subject. The second volume, "Space Research and Exploration" (Eyre and Spottiswoode, 221 pp., 25*s*.), is edited by D. R. Bates, F.R.S., of Queen's University, Belfast. Whereas in the first book technical details provide the bulk of the material, in the second general scientific principles are emphasised, and thus the two volumes are not in competition with each other but are complementary. Twelve contributions are published, dealing among other subjects with exploration of the upper atmosphere, cosmic radiation and meteor hazards, interplanetary orbits, and the difficulties of space navigation. Although Britain may be too poor, or too late, to take an active part in space travel which Prof. Bates calls "mankind's greatest adventure", there is no doubt that British scientists are actively concerned in the preliminary work. We have now reached the stage where "the possibility that space-travel may become a reality within a few decades cannot be lightly dismissed", to quote D. R. Bates once more. It is pleasing to note that this stage is well recorded by the work of British scientists.

The British Society of Rheology has issued a small leaflet setting out its aims, objects, and activities. Rheology is the science of the deformation and flow of matter, and research work carried out in this science is published quarterly in the Bulletin of the Society. Abstracts of foreign-language journals and proceedings are listed in this Bulletin, and the proceedings of conferences held quarterly in England are also available. Copies of the leaflet may be obtained from the Hon. Secretary, Mr N. Wookey, 52 Tavistock Road, Edgware, Middlesex.

The "Proceedings of the Plant Protection Conference 1956" have been published by Butterworths Scientific Publications (price 50*s*.) in conjunction with Plant Protection Ltd. The papers and discussions are a record of many of the fundamental aspects of crop protection and possible future trends, and should be a valuable work of reference for those concerned with agriculture and horticulture.

"The UNESCO Source Book for Science Teaching" published by Educational Productions Limited, East Ardsley, Wakefield, Yorkshire, price 15*s*., is designed to show teachers of elementary science how effective apparatus can be prepared from easily obtained sources. There are more than 400 illustrations covering over 500 pieces of apparatus which demonstrate principles of heat, light, magnetism, electricity, measurement and properties of matter, weather studies and astronomy, chemistry and biology. There are also sections on the arrangement of class and demonstration lessons, the use of visual aids in science, and recent materials useful in science teaching, laboratory recipes, charts, and tables.

Vol. 117, 1956, of the "Journal of the Royal Agricultural Society of England" (John Murray Ltd) contains articles on East Anglian Farming, Management and Good Farming, Grass for Feeding the Dairy Herd, Wild Oats, Temperature Requirements of Horticultural Crops, and Foot-and-Mouth Disease.

LETTERS TO THE EDITOR

Ancient Mexican Religion

Sir:

I was agreeably surprised to see that the eminent Americanist, Cottie Burland, was sufficiently interested in my book, "Burning Water", dealing with the religious thought of ancient Mexico, which appeared in London last March, to devote a generous critical review to it (DISCOVERY, April, p. 172). Words of praise or blame from him are important to anyone engaged in studying prehispanic cultures.

Mr Burland reproaches me with forgetting that the first Quetzalcoatl, ruler of the Toltecs, was far later in time than the beginnings of the belief in the god Quetzalcoatl, who was the Morning Star. I do not know what his basis is for such an affirmation. The fact is that the sixteenth-century documents, dictated by Spanish and indigenous chroniclers—which are the only direct testimony by which the archaeologist can assess his discoveries—speak of one Quetzalcoatl only, always with the same qualities and undergoing the same adventures: he is exclusively the chief of the Toltecs, the bearded man who one day, because of a sin he had committed, abandoned his kingdom and was finally transformed into the Morning Star. Some versions say that he was transformed into the planet after having thrown himself on to a bonfire; others, that he rose to the luminous regions of the new-born Sun, beyond the seas, on a raft made of serpents. In other words, nowhere does the man transformed into god appear dissociated from the Morning Star. To this I add the archaeological proof: after six years of careful study of Teotihuatecan iconography, I can testify that Quetzalcoatl appears in that centre with the same attributes, the same symbolism, and in the same religious complex as he does in later cities or in the Codices, which makes it impossible to believe in the existence of two separate entities, one appearing earlier than the other.

I also disagree with a statement Mr Burland makes, commenting on my book in *The Tablet*, ". . . the Rain God Tlaloc was undoubtedly the chief deity of the Teotihuatecans". Excavations at Teotihuacan over the last fifteen years contradict this. In my book I refer extensively to the results of these explorations, and would only mention here the palace which I discovered during two seasons of digging, in 1955–7. It is very important, forming as it does the only complete Teotihuatecan architectural complex known up to the present. There is no doubt at all that this palace is dedicated to Quetzalcoatl: for two images of Tlaloc there are five plumed serpents and also various others closely linked with the doctrine of Quetzalcoatl, as for instance his twin Xolotl, the Knights Eagle and Tiger, the sacrificial knives, and the cactus of penitence. The frescoes of a spacious living-room contain, several times repeated, the image most symbolic of Quetzalcoatl: that which represents him as Man-Tiger-Bird-Serpent. And there are two images which, since they correspond with extraordinary exactness to the content of the myths, definitely establish the relationship of the King of the Toltecs with Teotihuacan. One of these, 3·4 metres long, represents a plumed serpent drawn with such powerful dynamic force that it moves freely in a space which, because of the colour and also the motifs, is reminiscent of sky and sea. Erect on the animal is a figure which the clear indications in the myths show to be no other than Quetzalcoatl. It is noteworthy that the room containing this fresco is at the extreme east of the palace, and that the serpent-raft points towards the east. The other image, decorating a beautiful red-painted vase, shows the face of Quetzalcoatl. The beard, the head-dress like a mitre, and the severity of the eye show that we are in the presence of the legendary Toltec king, author of the moral and religious laws which prevailed until the end of prehispanic times. The plumed serpent which accompanies the head dissipates all doubt: resting on the mat, which is the symbol of power, this head of a reptile is a hieroglyph of "Our Lord Quetzalcoatl".

Mr Burland points out errors in the references to the Codices. I should make it clear that, in spite of their similarity to the Codex Rios, Figs. 64 and 65 belong, as I said, to the Codex Borbonicus and appear on pages 3 and 17 of that document. I acknowledge that by an error I cited Codex Nuttal instead of Vatican B in Fig. 35.

But I confess surprise that Mr Burland reproaches me with the interpretation I give to certain motifs from the Codices. If I had interpreted these images according to the naturalistic criteria which he sets against mine, my book would never have deserved his remark in *The Tablet* that it ". . . expounds the inner personal initiation of the ancient priests—sacrifice, complete sacrifice, of one's body in order to free the spirit for the contemplation of the Central Fire of the Universe. . . . After reading it, one can see more clearly why the Mexican Indians accepted the Catholic faith so easily and naturally." A naturalistic interpretation is precisely what has victimised the religious thought of ancient Mexico and left it supposedly on the margins of the great universal systems: cut off from its true roots, the most elevated of religions is fatally converted into an inert mass of utilitarian forms and ingenuous fancies. It is the error of positivism that it considers material needs to be the moving-force of interior activity, and that it finds what it considers a satisfactory answer to the mystery of existence in the scientific dissection of the visible world. I am in such disagreement with agrarian and meteorological interpretations, that I wrote my book in the hope that I might contribute towards freeing pre-Columbian religion from the positivist prejudice which conceals its spiritual greatness. To believe that the need for rain, for example, could possibly inspire the profound vision of the universe implicit in this mythology and symbolism, and the magnificent art which is its reflection, is dangerously to neglect the true process of human creation.

I began this letter by thanking Mr Burland for his praise. I add now that I am still more grateful for his criticism: they have allowed me to reply, although in a fragmentary way, to the chief objections my book will inevitably arouse, and they have facilitated conversational exchange, which is the only solution to the lack of understanding which is such a drawback among specialists. LAURETTE SÉJOURNÉ.

Mexico City.

Space Travel and Ageing

Sir:

I concentrated my argument into one syllogism to avoid further red herrings: I shall therefore not follow the new ones that Prof. McCrea has introduced, but consider only his comments on the three points.

He says that premiss (1) (that according to relativity no observable phenomenon will show that one body rather than the other has moved) is "demonstrably false", and cites a number of such phenomena, including the supposed difference of clock readings. But then he adds: "Of course, it is not necessary to say that 'one rather than the other has moved'." So, after all, (1) is true but (2) is false. ((2) says that if one clock only were retarded by a quantity depending on the motion, that phenomenon *would* decide that that clock only had moved.)

So what McCrea says is this. A's absolute time for the journey is T, and C's absolute time is $T\sqrt{(1-V^2/c^2)}$, but that does not mean that A has velocity zero and C velocity V; you are free to say that A has any velocity V_1 and C any velocity V_2, so long as their resultant is V.

I submit that this is absurd. If you gear an absolute phenomenon to a single variable V, that variable must represent something absolute; why, otherwise, is only C's time affected by it? McCrea must now give up his absolute phenomenon of a time-difference on reunion, or else give up the principle of relativity of motion: there is no middle course.

HERBERT DINGLE

Purley, Surrey.

Sir:

What McCrea says is not what Prof. Dingle says he says.

W. H. MCCREA.

Royal Holloway College.

This correspondence must now cease. The Editor.

FAR AND NEAR

English-Electric P.1B

In view of the ever-greater complexity of fighter aircraft, and because guided missiles are considered to be more effective as anti-aircraft defence than fighter planes, many experts think that the days of piloted fighter aircraft are rapidly coming to a close. It is therefore interesting to see that, what may well prove to be the first and last supersonic RAF fighter, is reaching its final test stages and is about to go into production.

The first English-Electric P.1B fully supersonic twin-jet fighter made its maiden flight recently at Warton Aerodrome, Lancashire. A production order for the P.1B has been placed by the Ministry of Supply, and the plane will go into service with Fighter Command of the Royal Air Force as an all-weather day and night fighter. The P.1B has been designed as a complete weapon system. This means that the extensive armament, radar, and radio aids are integral parts of the aircraft and have not been treated as extra items to be added in stages. This equipment—long-range radar to find enemy aircraft by day and night and in all weathers, radio and navigation aids for operations under the worst conditions, and a dual armament of guided missiles and 30 mm. Aden cannon—is as important as the aircraft's supersonic speed. The single-seat aircraft is powered by two Rolls-Royce Avon turbo jets with reheat. It has a very high rate of climb and can cruise economically on one engine. Although externally similar to the P.1A research aeroplane, the P.1B has a redesigned fuselage to accommodate the much more powerful engines, and the large volume of radio, radar, and armament equipment. The cockpit is refrigerated, and air below freezing point is pumped to it as well as to much of the equipment in the aircraft, in order to overcome the effects of kinetic heating (the so-called "thermal barrier") at high speeds. The refrigeration unit produces 150 times as much cooling air as an average domestic refrigerator.

Course on Digital Computers

The British Council is to organise a fortnight's course on digital computers. It is designed to provide a survey of available machines, programming, and machine applications, and will comprise lectures, discussions and visits to computing laboratories and installations in universities and industry. Since much of the pioneer work on these machines was carried out in Great Britain, it is possible to have a number of the world's leading experts to conduct the course.

The basic lectures will be given in London, where visits to various computing establishments will also be arranged. These visits will illustrate the academic development of computer design and programming, the practical applications of the results of research in the laboratories of computing machine manufacturers, and the uses to which computers are put in various types of commercial and manufacturing enterprise. These visits will provide an opportunity not only of seeing computing equipment in use, but also of discussing practical problems with workers in the field. It is hoped that visits may also be arranged to the Universities of Cambridge and Manchester, and to the Computational Laboratory, Birkbeck College, University of London. At Cambridge it will be possible to see the EDSAC, which was the first electronic digital computer using a stored programme to come into operation; an advanced machine—the EDSAC (2)—will also be shown. At Manchester visits will be paid to the University mathematical laboratory and also to a manufacturing establishment. At Birkbeck College, it is hoped to show some of the work in progress on non-numerical applications of computers. It is also proposed to demonstrate the APEXC, perhaps the most compact digital computer in industry.

This course is intended for scientists in industry, university teaching, and research from overseas, who wish to become better acquainted with recent British advances and practice in the use of computers in solving scientific and technical problems. Applications will also be considered from suitably qualified persons engaged in an administrative capacity in industry or in services employing or planning to employ computers for the solution of engineering problems. A knowledge of the basic principles of computers will be assumed, and the time devoted to introductory study will be limited.

There are vacancies for only fifteen members, and the fee is £42. Applications should be made to the British Council, 65 Davies Street, London, W.1.

Honour for Arctic Explorer

The Royal Geographical Society has announced that the Queen has approved the award of the Founder's Medal to Sir George Binney for services to Arctic exploration. Sir George won the D.S.O. in the RNVR during the war. The Germans described him as the brains behind the breaking of the blockade of the Skagerrak by ten Norwegian ships in 1942. He was knighted in 1941 for "special services in the supply of valuable war material".

A second royal medal winner is Prof. Adito Desio, director, Geological Institute, University of Milan. He receives the Patron's Medal for Himalayan ex-

ploration and research. Prof. Desio led the successful Italian expedition in 1954 to K2 (28,250 feet), the second highest mountain after Everest.

The VC Portable Microfilm Reader

The VC Microfilm Reader is contained in a carrying case and is portable and easily erected. Both hand-operated and motorised models are available. When the case is opened it is only necessary to tilt the head of the machine and to plug in and it is then ready for use. The image is projected downwards on to the desk or table in the natural reading position. No special screen is required and any white sheet of paper or card can be used. As there is no translucent screen there is no glare or eye strain, and this is a particularly important feature where concentrated work is necessary. The head can be rotated through 360° (180° in the case of the motorised reader) and it is therefore possible to read the film irrespective of the way in which the page has been photographed.

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If the folding case is not used the reader can project on to a wall or ceiling and can be used as a projector. It can also be used as a filmstrip projector.

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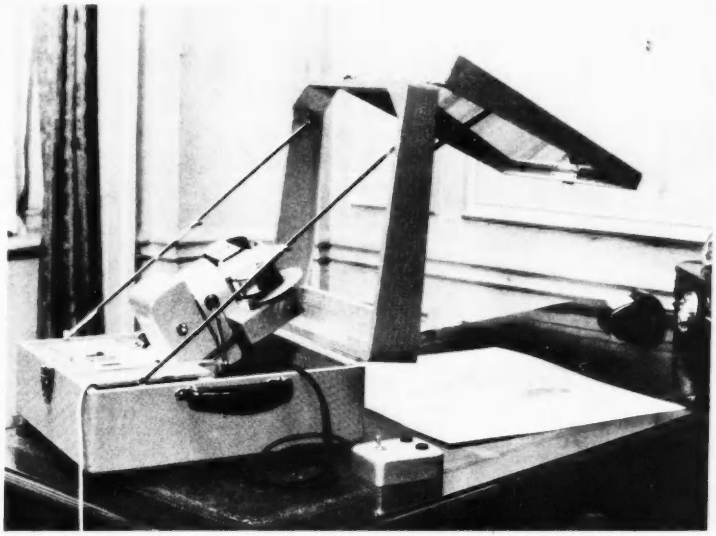


Better Reservoirs

Successful tests (just completed) of CSIRO's Mansfield Process on a large reservoir at Broken Hill, Australia, will mean that the world's reservoirs can provide more water. Over the past fourteen weeks evaporation from the Stephen's Creek reservoir, Broken Hill's main water supply, has been reduced by 37%. More than 200 million gallons of water, which is equivalent to six weeks' summer consumption in Broken Hill, has been saved. From this experiment the estimated cost of the water saved is one penny per thousand gallons. Under less favourable conditions the cost of saving water will be greater but it should not exceed 6*d.* per thousand gallons. This is a small cost in comparison with alternative means of obtaining and conserving water.

CSIRO and the Broken Hill Water Board started a joint research programme in December 1955, under the supervision of the inventor of the process, Mr W. W. Mansfield of CSIRO's Division of Industrial Chemistry. The object was to modify the process to work on large areas of water. The raft method, which is being used extensively now on small areas of water, is uneconomic on large areas because of difficulties associated with the action of wind and wave. However, by December 1956 an alternative method had been found which produced a satisfactory film of cetyl alcohol by feeding on to the surface of the reservoir a solution of cetyl alcohol in a solvent. With this new method a satisfactory film has now been maintained for more than three months in spite of exceptionally high wind velocities. About one foot of evaporation has been saved over an average area of 930 acres.

The successful application of the Mansfield process to large areas of water will be of tremendous value not only to Australia but to the world. By preventing water from evaporating the effective capacity of water storages is increased. For the whole of Australia the value of these savings would amount to tens of millions of pounds, a figure which would be multiplied many times throughout the world.

Honour for British Inventor

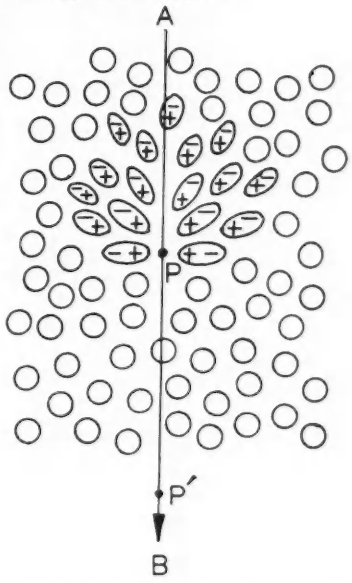
Dr Paul Eisler of London has been made an officer of the French "Order of Merit for Research and Invention" for his invention and pioneering work of printed circuits. The investiture took place in Paris last March.

Two Expeditions Supplied with Terramycin

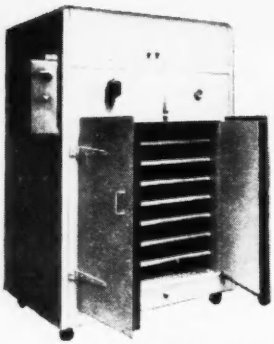
Two expeditions setting out this year are including supplies of the antibiotic Terramycin in their medicine chests. They are the *Mayflower II*, which sailed to America in April, and the Queen's University (Belfast) Expedition to Central West Spitsbergen, due to leave in the summer.

Errata

Dr J. V. Jelley apologises for an error in the two simple equations in his article on Cerenkov Radiation in our April issue, p. 146. The equations should have read $AB=\beta c\times\Delta t$ and $AC=(c/n)\times\Delta t$. We also apologise for having inserted an earlier sketch for Fig. 1; this should have appeared as follows:



In the article by R. A. Lyttleton on "The Swing of a Cricket Ball", p. 186 of our May issue, the statement "Moreover a whole century later, Noah Mann . . . was able to make the ball 'curve the whole way' . . ." was printed. This should, of course, have read "earlier".



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Application form and further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S 128/57 and stating date of birth.

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Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S59/57.

Interview Boards sit at intervals, as required. Early application is advised.

LABORATORY TECHNICIAN required by UGANDA GOVERNMENT Veterinary Services and Animal Industry Department either (*a*) on probation for pensionable employment or (*b*) on contract for one tour with gratuity at rate 13½% of total salary drawn, and prospect of transfer to pensionable staff. Salary scale (including inducement pay) £846 rising to £1566 a year. Commencing salary according to experience. Outfit allowance, £30 usually payable. Free passages. Liberal leave on full salary after each tour of 30–36 months. Candidates, preferably under 35, must be A.I.M.L.T., with experience in pathological, bacteriological, and haematological techniques. Knowledge of protozoology an advantage. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M3/43804/DI.

EXPERIMENTAL OFFICER/ASSISTANT EXPERIMENTAL OFFICER required by the ATOMIC WEAPONS RESEARCH ESTABLISHMENT, Aldermaston, Berks, to take charge of an instrument development laboratory and carry out advanced experimental and development work on prototype instruments. Duties will include the organisation and supervision of inspection, test and maintenance procedures for oscillograph recording cameras and ancillary equipment.

G.C.E. in five subjects, including English (ordinary level) and two scientific/mathematical subjects (advanced level) or equivalent qualification is required. Alternatively H.N.C. (Mech. Eng.). Applicants should be conversant with engineering drawings and have experience of fine measurement and adjustment of intricate mechanisms. Experience of workshop practice, optical instruments and photography an advantage.

Applicants for the Experimental Officer post should be at least 26 years of age.

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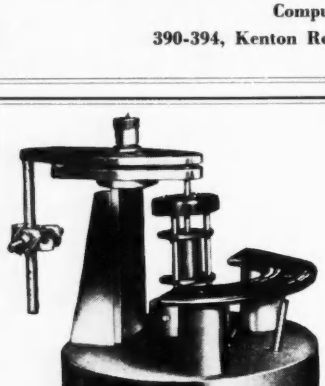

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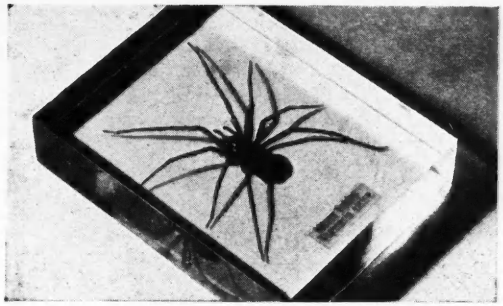

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